VALTION MAATALOUSKOETOIMINNAN JULKAISUJA N:o 152

PUBLICATIONS OF THE FINNISH STATE AGRICULTURAL RESEARCH BOARD No. 152

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Helsinki 1957. Valtioneuvoston kirjapaino

Preface

One of the most important tasks of Finnish agricultural research of today is to further grassland cultivation, and, above all, to increase the reliability of the crop and the seed yield in our most important fodder plant, the red clover. Since pests are notoriously considerable factors in lowering the seed and fodder yields of red clover, the Department of Pest Investigation, Agricultural Research Centre, has paid continual attention to the investigation and control of pests on this plant. In the course of years, a considerable quantity of observation material has been collected. For the first objective of detailed studies, the lesser clover leaf weevil *(Phytonomus nigrirostris* Fabr.) has been chosen, as it is one of the most important red clover pests in this country, together with *Apion apricans* Herbst., *Haplothrips niger* Osv., *Dasyneura leguminicola* Lintn. and *Ditylenchus dipsaci* (Kühn) Filipjev.

These studies of the lesser clover leaf weevil have been carried out in the Department of Pest Investigation, Agricultural Research Centre, at Tikkurila (16 km north-east of the city of Helsinki) during 1953—1955. Attention was paid chiefly to the biology of this species, since a knowledge of its habits is a necessary basis for control, as in the case of other pests. Although preliminary control experiments have been made, they are not reported here. The finding of control methods for use against the species will be part of the investigation programme of the coming years, to be carried out parallel with continued investigation of certain other pests of leguminous fodder plants. — Studies of the lesser clover leaf weevil have been carried out in the Department of Pest Investigation previously, in particular by the late head of the Department, Professor Yrjö Hukkinen, Dr. Agr. and. F., and by Mr. Niilo Rasinmäki, M. A.

In the spring of 1955, assistance was given by Miss Pirkko Tanskanen, M. Agr. and F., and Mr. Erkki Junnikkala in the observations and in looking after the rearings. To them, as well as to the head of the Department of Pest Investigation, Professor Veikko Kanervo, Dr. Agr. and F., who has assigned this study to us and guided us in many ways, we express our gratitude. Further, our thanks are due to Mrs. Sirkka Carlson for

translating our manuscript into English and to Miss HELEN M. TURNBULL for linguistic revision.

Financial support for this work, for which we are indebted, has been received from the Emil Aaltonen Foundation and from the State grants for young scientists.

Tikkurila, April 20th, 1956

The Authors

Contents

I. Survey of earlier investigations

Abroad, particularly in North America, some relatively limited investigations have been carried out on the lesser clover leaf weevil (*Phytonomus nigrirostris* Fabr.). HOUGHTON (1908) was the first to publish detailed observations on its life cycle. WEBSTER (1909), in addition to its biology, has dealt with the introduction of the weevil into North America and its spread there. The life habits of the species have been described most thoroughly by DETWILER (1923) and UNDERHILL (1924). HUDSON and WOOD (1924) have included the duration of the various stages of development in their observations. The most recent study of the species is presented in the publication of SERVADEI (1944), in which he has described in detail the morphology of the various developmental stages and the anatomy of the larva, and has also given some account of the biology of the species.

In Finland, C. R. SAHLBERG (1835) is the first to mention the species. In »Reports on the occurrence of pests in Finland», the species is first mentioned in 1911 (REUTER 1914). The first actual observations on the lesser clover leaf weevil as a pest have been made by the late head of the Department of Pest Investigation, Professor *Yrjö Hukkinen*, in 1913 (LINNANIEMI 1915). For several years subsequent to 1913, *Hukkinen* made observations on its habits of life and the damage which it inflicted in this country, and he presented some of his results in a number of articles (HUKKINEN 1915 and 1920). In 1929, Mr. *Niilo Rasinmäki* made observations in the Department on the habits of the species. Some information regarding the studies reported in this paper has been published previously (MARKKULA 1955 and MARKKULA and TINNILÄ 1955).

II. Methods of investigation

The investigations made at the Department of Pest Investigation, Agricultural Research Centre, at Tikkurila (16 km north-east of the City of Helsinki) in 1953—1955, were carried out partly as field investigations in field containing leguminous fodder plants and partly in the form of various rearing experiments in the Department's insectarium. In other localities, there have mainly been observations only on the time of occurrence and the abundance of the various developmental stages.

The field investigations are chiefly based on samples taken from the actual experimental areas and the observations made on them. The red clover fields used in the investigations were of varying size, but for the actual experimental area an area of some 20 ares was taken from each field, except in the case of experimental area IV., which was used in its entirety (5 ares). The actual experimental areas were situated in a field belonging to the Agricultural Research Centre at Tikkurila. In all cases the red clover in question was the Tammisto red clover.

Actual experimental areas in 1953

Experimental area I. First year red clover field. Sown on May 27th, 1952, seed 25 kgs per hectare. Rather dense and rich growth. Area 41 ares.

Experimental area II. First year red clover-timothy field. Sown on May 27th, 1952. Red clover seed 10 kgs per hectare, timothy seed 20 kgs per hectare. Rather dense and rich growth. Area 2.5 hectares. Some samples were also taken from this experimental area in the following year.

Actual experimental areas in 1954

Experimental area I A. Identical with experimental area I of the previous year, now a second year field. Clover growth somewhat less dense, more weeds.

Experimental area III. Second year red clover field. Sown on June 2nd, 1952. Seed 32 kgs per hectare. Dense, rich growth. Area 43 ares.

Actual experimental areas in 1955

Experimental area IV. Second year red clover field. Sown on May 6th, 1953. Seed 14 kgs per hectare. Fairly dense and rich growth. Area 5 ares, used in its entirety as experimental area. Some samples taken in the previous year.

Experimental area V. Second year red clover field. Sown on June 3rd, 1953. Seed 18 kgs per hectare. Dense, rich growth. Area 24 ares. Some samples taken from this experimental area in the previous year.

Experimental area at Espoo. (Espoo is a neighbouring community of Helsinki.) In the summer of 1955, there was, in addition, a very rich second year red clover-timothy field (timothy less than 10 pc) of some 10 hectares available for experiments. Part of it was divided up into 14 plots of 10 ares each. In this area, observations were made to ascertain various factors, including the abundance of the species and the location of the eggs.

A part of the experiments carried out on the field were based on netting samples. The net used had a circular opening with a diameter of 33 cms, and its handle was 75 cms in length. Samples were taken at a slow walking pace at a distance of at least 5 metres from the edge of the experimental area concerned. Netting samples were collected from the actual experimental areas during the period of growth, usually at intervals of 7—10 days, at about 2 p. m. If it was raining at this time, or if the growth was very wet, owing to previous rain, sampling was postponed till the next dry day. The sample usually consisted of 100 double sweeps. — On the basis of the netting samples, observations were made on the abundance of both hibernated adults and adults of the new generation.

The field experiments were also based on shoot samples. »Shoot» means here a branch beginning at the root of a clover specimen, i. e., starting practically at ground level. Shoots were collected at regular intervals from various parts of the experimental area, at a distance of not less than 5 metres from its edge, so that one clover specimen yielded only one or two shoots for the sample. The shoot samples were generally taken from the actual experimental areas simultaneously with the netting samples. Usually each sample consisted of 100 shoots. — On the basis of the shoot samples, observations were made on the abundance of eggs, larvae and pupae in the experimental areas.

In addition to the netting and shoot samples, numerous observations were made in the field regarding the various developmental stages of the species, their abundance and their habits of life.

Insectarium investigations. Rearings were carried out in a compartment with wire mesh walls and a glass roof in the insectarium of the Depart-

Fig. 1. The insectarium of the Department of Pest Investigation, Agricultural Research Centre, Tikkurila.

ment of Pest Investigation (Fig. 1), where temperature and humidity conditions corresponded fairly closely to those prevailing outdoors, as was proved by measurement.

The majority of the insectarium experiments were carried out as tube rearings (Fig. 2). The shoots of the plants under experiment were placed in water-filled glass bottles, each having a capacity of 30 grams, and the orifices were plugged with cottonwool. After the insects had been placed on the plants, these were then covered up with glass cylinders, the upper ends of which were covered with glass batiste, while the lower ends fitted closely to the upper parts of the bottles. The glass cylinders were 12 cms in height and 2.9 cms in diameter. New shoots were generally substituted daily for the old ones. — In the tube rearings, the observations included determination of the number of eggs of the species, the positions of the eggs, and the duration of the various developmental stages.

In the cage rearings the cages (Fig. 3) used had a height of 70 cms and a basal area of 30 cms square. Two sides and the top were of glass, the other two sides being of glass batiste cloth. The cages were firmly placed on a box filled with soil, in which the trial plants had been planted. — In these cage rearings, the habits of the various developmental stages and the behaviour of the species in respect to food plants were included in the observations.

In addition to tube and cage rearings, bag rearings were also employed. In these, the experimental plant, or a part of it, was covered by glass batiste rearing bags after the weevils had been placed on it. The experimental plants had been planted in flower pots. — In the bag rearings the chief object of the investigations was the behaviour of the species with regard to the host plants.

Fig. 2. Arrangement of the tube rearings carried out in the insectarium.

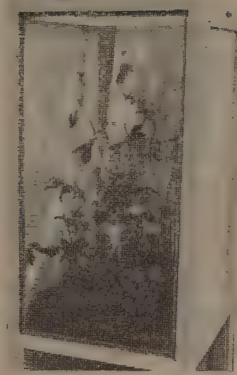


Fig. 3. Rearing cage, used for cage rearings in the insectarium.

The basis to these investigations was provided by the notes of *Hukkinen* and *Rasinmäki*, kept in the archives of the Department of Pest Investigation (cf. p. 7), as well as by information gathered in the Department from other observations. Facts cited from these sources are indicated in the text by the words 'p.dept. arch.' in brackets.

III. Distribution

According to literature, the lesser clover leaf weevil is known all over Europe, from Norway and Finland to Italy, and from Great Britain to the Soviet Union. Its area of distribution also includes the Mediterranean countries, not only those in Europe, but those in Africa and Asia Minor as well. The species was probably introduced into North America about the middle of last century (WEBSTER 1909 and UNDERHILL 1924). From the interior of the continent it spread westwards and as early as 1916 it was found in the state of Montana (COOLEY 1916). The species is known as an important pest in most European countries, as well as in the United States and Canada.

C. R. SAHLBERG (1835) mentions the lesser clover leaf weevil as occurring rather infrequently in Southern Finland. J. R. SAHLBERG (1900) lists the following natural provinces of Finland as the areas where it is found: Al, A, St, N, T, S, Ka, K, Kr and Oa.

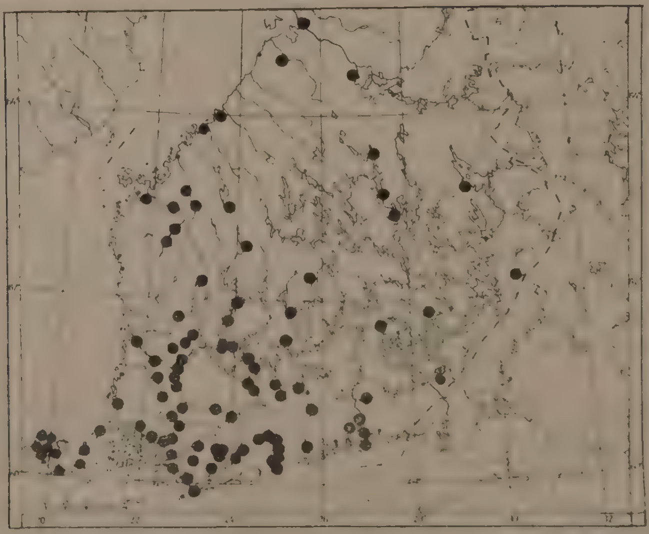


Fig. 4. The distribution of the lesser clover leaf weevil in Finland. Places where its occurrence is known are marked by dots.

The information given in Fig. 4 regarding its occurrence is based on »Kertomuksia tuhoeläinten esiintymisestä maassamme» (Reports on the occurrence of pests in Finland) (Hukkinen & Vappula 1935 and 1936, Linnaniemi 1915, 1916,1920 and 1935, Reuter 1914 and Vappula 1938, 1951 and 1952), on unpublished information in the archives of the Department of Pest Investigation, on material in the Entomological Museum, Univ. of Helsinki, and in the Institute of Agricultural and Forest Entomology, Univ. of Helsinki, and on observations made in 1953—55 in connection with the present study. As will be seen from the map, the species has been found in this country as far north as Oulu (latitude approx. 65° N.). It is possible that it occurs even farther north, although no observations are known. In its area of occurrence the species is common and is found in great numbers, particularly in the southern parts of the country. — In Sweden and Norway, the area of occurrence of the lesser clover leaf weevil appears to be approximately the same as in Finland (Hansen *et al.* 1939).

IV. The developmental stages and their biology

The adult lesser clover leaf weevils hibernate mainly in red clover fields. They begin oviposition in the spring or early summer. The number of larvae usually reaches a peak about midsummer. The larvae pupate in a cocoon and the adults of the new generation generally appear in July. Towards the end of the summer the latter retire into hibernation. In this country the species produces one generation a year.

In Finland, the lesser clover leaf weevil is chiefly found in red clover fields, where it causes the greatest damage. The species also lives on some other cultivated and wild leguminous plants. The findings on the biology of the various stages of development presented in this chapter (IV). are based on observations of specimens living on red clover (Tammisto red clover) in the field, or in the insectarium.

1. *The egg*

a. Appearance and size

The egg is oblong, with the ends bluntly rounded. Under the epidermis of the red clover leaflet the newly deposited eggs appear to be of a light green colour: in actual fact, they are practically colourless (Fig. 5). Gradually they change to a darker colour, becoming almost black before hatching. For example, eggs with an incubation period of 8—10 days begin to get darker one day after oviposition. When 5—6 days old they are nearly black, at one end at least, and after about 7 days, they are virtually black all over.

Data on egg size given in literature are cited below, and the results of measurements taken from 71 eggs in the present study are included.

	Length	Width
HOUGHTON (1908)	0.55—0.6 mm	0.35—0.4 mm
WEBSTER (1909)	0.55—0.63 »	0.35—0.36 »
DETWILER (1923)	0.56 »	0.36 »
UNDERHILL (1924)	0.61 »	
SERVADEI (1944)	0.5 —0.6 »	0.2 —0.3 »
Present study	0.53—0.75 »	0.23—0.44 »
Present study (average)	0.64 »	0.34 »

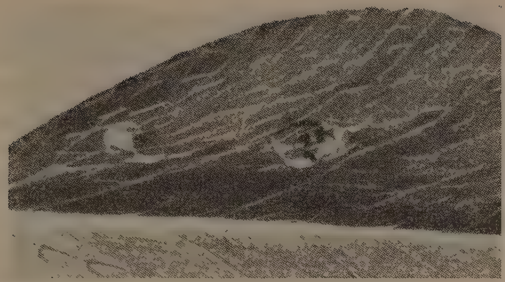


Fig. 5. A group of three eggs and one single egg underneath the epidermis of the lower surface of a red clover leaflet.

On the basis of the figures given, it may be noted that the eggs measured in this study were somewhat longer that those previously described in literature. It may also be seen that they were a little thinner than those mentioned in literature, with the exception of those measured by SERVADEI (1944). It would be of interest to ascertain whether the differences in size are real, or whether they are due to the small number of eggs measured.

b. Location

According to WEBSTER (1909) and DETWILER (1923), the species lays its eggs in both the leaves and the stipules of red clover. The former considers oviposition in the stipules to be normal. UNDERHILL (1924) has found the most eggs in the stipules, and fewer in the leaflets, petioles and stems. Observations on the location of the eggs were made in the tube rearings in the insectarium, and on the basis of shoot samples from the actual experimental areas at Tikkurila and from the experimental area at Espoo (see pp. 8—9). The results of the observations are presented in Table 1.

Table 1. Location of eggs in red clover in tube rearings in the insectarium and in the experimental areas at Tikkurila in 1954—1955 and in the experimental area at Espoo in 1955.

Location of eggs	Number of eggs in tube rearings in the insectarium		Number of eggs on shoot samples in the field			Total of eggs	
	1954	1955	Tikkurila 1954	Tikkurila 1955	Espoo 1955	Number	%
Leaflets	1 729	1 895	51	55	244	3 974	99.49
Stipules	3	6	8	0	0	17	0.43
Petioles	1	2	0	0	0	3	0.08
Total of eggs	1 733	1 903	59	55	244	3 994	100.0

Out of nearly 4000 eggs, 99.5 pc were located in the leaflets and only 0.5 pc elsewhere, in the stipules and petioles. Apart from the observation series that form the basis of these results, in the field both single eggs and groups of eggs were found a few times in the stipules, but not once in the petioles.

The female of the species normally deposits her eggs underneath the epidermis. This is practically always the case when the eggs are laid in the leaflets and stipules. Only in exceptional cases were eggs found to have been left either entirely on the surface of the leaflet, or in an indentation in the leaflet caused by a broken epidermis. The eggs found in the petioles were all located in the latter manner. Apparently the depositing of eggs on the surface or in an indentation made in the cellular tissue of the plant, without the protection of the epidermis, is a result of interrupted oviposition.

When about to lay, the female first perforates the epidermis of the leaf with her beak and then digs out (sideways from the hole) a small cavity in the cellular tissue, in which she lays her eggs (cf. Fig. 5, p. 15). Thus the eggs will be located beneath an intact part of the epidermis. The female usually drags her ovipositor about in the neighbourhood of the hole for some time before inserting it. In an instance cited by *Hukkinen* (p.dept., arch.), oviposition lasted 7 minutes. In this case the female laid 3 eggs. After oviposition, the female at once departs and does not cover up the hole with the cell tissue around it, as *Phytonomus meles* Fabr. does (LEHMANN and KLINKOWSKI 1942).

According to WEBSTER (1909), the lesser clover leaf weevil deposits its eggs beneath the epidermis either in the upper or in the lower surface of the leaflet. The majority of the eggs laid in the tube rearings in the insectarium (1733 eggs in 1954 and 1903 eggs in 1955) were located underneath the epidermis of the lower surface of the leaf: in 1954, 61 pc were so located, and in 1955, 57 pc. In the actual experimental areas at Tikkurila and in the Espoo experimental area, out of 338 eggs 71 pc were under the epidermis of the lower leaflet surface. The tube and bag rearings carried out to ascertain the choice of host plant and the number of eggs in different plants also gave corresponding results for red clover: out of 259 eggs 74 pc were found under the epidermis of the lower leaflet surface (Table 7, p. 49).

To summarise: the lesser clover leaf weevil usually deposits its eggs under the epidermis of the lower leaf surface of red clover. This is also the case with respect to other host plants; it seems, indeed, to be even more common with plants other than red clover (see Table 7, p. 49).

Usually the eggs were deposited from the same side of the leaflet as that where they were located, although they fairly frequently had also been deposited from the other side to underneath the epidermis of the opposite surface. Once or twice, it was found that the eggs had been pushed right through the leaf on to the opposite outer surface.

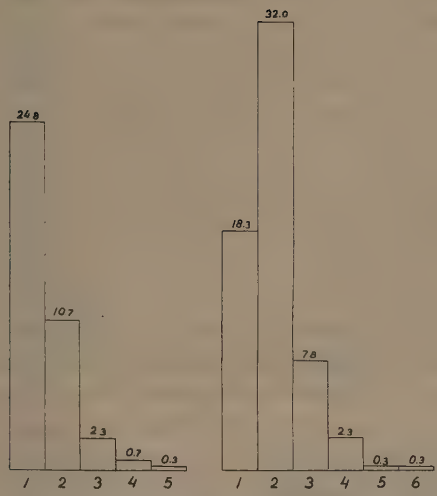


Fig. 6. Percentage of eggs according to groups under the epidermis of the upper surface (left-hand columns) and of the lower surface (right-hand columns) of the red clover leaf in the tube rearings in the insectarium in 1954. The figures at the bottom of the columns indicate the number of eggs in each group, and the figures at the top indicate the percentage of the total number of eggs (1 733).

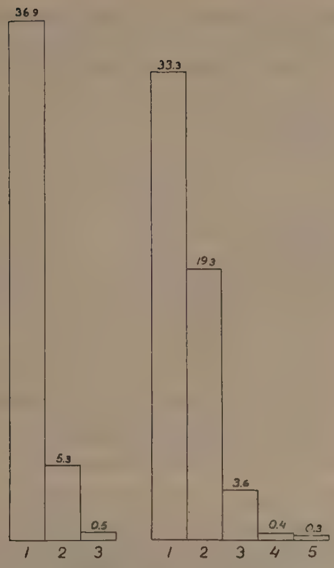


Fig. 7. Percentage of eggs according to groups under the epidermis of the upper surface (left-hand columns) and of the lower surface (right-hand columns) of the red clover leaf in the tube rearings in the insectarium in 1955. The figures at the bottom of the columns indicate the number of eggs in each group, and the figures at the top indicate the percentage of the total number of eggs (1 903).

Houghton (1908) reports that the eggs are located either singly or in pairs, and Webster (1909) has observed both single eggs and groups of 2—4. According to Detwiler (1923), single eggs are the most common, but according to Underhill (1924), groups of 2—3 eggs occur most frequently.

Observations made in this study on the incidence of egg groups of different sizes are reported in Figures 6 and 7 and in Table 2. As will be seen, in the tube rearing in the insectarium, the single eggs constituted 43 pc of the total number of eggs in 1954, and 70 pc of the total in 1955; in the actual experimental area at Tikkurila, they constituted 51 pc in 1954 and 68 pc in 1955; and in the Espoo experimental area they constituted 64 pc in 1955. Thus it can be noted that in 1954 less than half or only half (43—51 pc) the eggs were single, and in 1956 the majority (64—70 pc) of them were single. The greater frequency of single eggs in 1955 was probably due to the sub-normal temperatures prevailing at the time of oviposition, particularly

Table 2. Location of eggs according to groups in red clover in the actual experimental areas at Tikkurila in 1954—1955 and in the Espoo experimental area in 1955.

Place and year of observation	Eggs on upper leaflet surface						Eggs on lower leaflet surface								Eggs in stipules						Total number of eggs
	Singly		In pairs		Total		Singly		In pairs		In threes		Total		Singly		In pairs		Total		
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	
Tikkurila 1954.	12	20	4	7	16	27	16	27	16	27	3	5	35	59	2	4	6	10	8	14	59
Tikkurila 1955.	9	17	4	7	13	24	28	51	14	25	0	0	42	76	0	0	0	0	0	0	55
Espoo 1955 . . .	54	24	6	3	60	27	90	40	68	30	6	3	164	73	0	0	0	0	0	0	224
Total	75	22	14	4	89	26	134	39	98	29	9	3	241	71	2	1	6	2	8	3	338

in the early part of this period, which reduced both the number of eggs laid in a given period of time and the absolute number of eggs (cf. p. 20), thus at the same time causing a decrease in the number of groups of two or more eggs. — In the field, the greatest number of eggs found in the same leaflet was 7, and in the same shoot 10. Most usually there were only one or two eggs in the same leaf and even in the same shoot.

Figures 6 and 7 and Table 2 show further that the biggest egg groups were encountered underneath the lower surface of the leaves, and that, in general, groups of two or more eggs were clearly more frequent under the epidermis of the lower leaf surface than under that of the upper surface. Of the egg groups, those comprising two eggs were the most common. In 1954, eggs in pairs under the epidermis of the lower leaf surface even surpassed in number the single eggs in the same place. Groups of three or four eggs were rare. Out of the material of nearly 4000 eggs, there were three groups of five eggs and only one group of six.

c. Number of eggs

Detwiler (1923) reports that one specimen laid 294 eggs, or an average of nearly 7 eggs a day, and another about 200 eggs, averaging 4 a day. The greatest number of eggs laid in one day was 21 in the case of the former specimen, and 15 in the case of the latter. Hudson and Wood (1924) report that one specimen laid 141 eggs. The maximum number of eggs laid in one day was 37, and the next greatest was 23. The average daily number of eggs laid by one specimen is given as 6—7. In the experiments made by Underhill (1924), the greatest number of eggs was 303 and the average 109—142. The maximum number laid in one day was 13 and the average 1—3.

The number of eggs laid by the species was investigated in 1954—55 in tube rearings in the insectarium. The food plant was the Tammisto red

Table 3. Oviposition of six females in red clover in five-day cycles in the tube rearings in the insectarium in 1954.

Number of specimen	Beginning of experiment	First day of oviposition	May 20—21	May 22—26	May 27—31	June 1—5	June 6—10	June 11—15	June 16—20	June 21—25	June 26—30	July 1—5	July 6—10	July 11—15	July 16—20	Number of eggs	Last day of oviposition	Egg-laying period, days	Average number of eggs per day
1	7. 5	22. 5	0	47	52	15	35	34	27	23	18	11	21	5	0	288	12. 7	52	5.5
2	7. 5	22. 5	0	26	25	26	19	29	26	20	0	0	0	0	0	171	25. 6	35	4.9
3	8. 5	20. 5	10	55	47	25	34	26	34	30	14	12	9	4	0	300	12. 7	54	5.6
4	10. 5	20. 5	14	65	75	42	34	47	56	46	4	1	0	0	0	384	1. 7	43	8.9
5	25. 5	28. 5	0	0	36	30	29	44	52	50	21	26	17	18	5	328	20. 7	54	6.1
6	25. 5	27. 5	0	0	31	32	34	32	48	32	26	16	11	0	0	262	9. 7	44	6.0
Total			24	193	266	170	185	212	243	201	83	66	58	27	5	1 733			
Average			4.0	32.2	44.3	28.3	30.8	35.3	40.5	33.5	13.8	11	9.7	4.5	0.8	289	8. 7	47	6.1

clover, as in all the red clover experiments. In the spring, before the period of oviposition, the sample specimens were collected from the actual experimental areas at Tikkurila, except for specimen No 1 in the 1955 experiments (Table 4), which was brought from a red clover field at Fiskars (latitude 60°05′ N. and longitude 22°40′ E.). In that year, specimens Nos 7 and 8 may have laid a few eggs before the commencement of the experiments.

Tables 3 and 4 show that the number of eggs laid by six females in 1954 was 171—384 (average 289), and the number laid by eight females in 1955 was 104—409 (average 238). Thus there is an appreciable difference in the

Table 4. Oviposition of eight females in red clover in five-day cycles in the tube rearings in the insectarium in 1955.

Number of specimen	Beginning of experiment	First day of oviposition	June 28. 5—1. 6	June 2—6	June 7—11	June 12—16	June 17—21	June 22—26	June 27. 6—1. 7	July 2—6	July 7—11	July 12—16	July 17—21	July 22—26	July 27—28	Number of eggs	Last day of oviposition	Egg-laying period, days	Average number of eggs per day
1	26. 5	28. 5	16	18	16	18	3	13	9	9	2	0	0	0	0	104	8. 7	42	2.5
2	28. 5	31. 5	18	52	29	22	18	44	35	36	33	5	0	0	0	292	14. 7	45	6.5
3	28. 5	31. 5	22	51	31	38	24	48	38	37	29	23	3	0	0	344	20. 7	51	6.7
4	28. 5	31. 5	14	34	20	30	17	44	27	25	8	0	0	0	0	219	8. 7	39	5.7
5	28. 5	2. 6	0	29	37	30	24	62	64	38	53	48	26	0	0	409	21. 7	50	8.2
6	31. 5	2. 6	0	8	5	23	16	22	42	31	47	19	0	1	0	214	22. 7	51	4.2
7	2. 6	3. 6	—	18	13	24	15	45	25	8	0	0	0	0	0	148	6. 7	34	4.4
8	2. 6	3. 6	—	25	14	15	7	16	24	19	18	21	13	0	1	173	28. 7	56	3.1
Total			70	235	165	200	124	294	264	203	190	116	42	1	1	1 903			
Average			11.7	29.4	20.6	25.0	15.5	36.8	33.0	25.4	23.8	14.5	5.3	0.1	0.1	238	16. 7	46	5.2

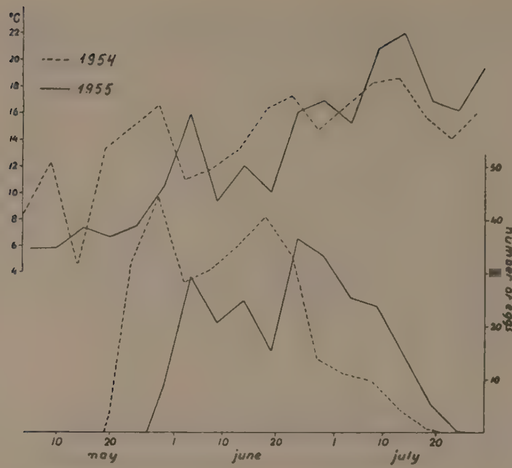


Fig. 8. The correlation between the number of eggs laid in a given time and the temperature. The average number of eggs per five-day cycle, laid by six females in 1954 and eight females in 1955 in the tube rearings in the insectarium, and the average temperatures at the time of oviposition per five-day cycle are shown.

averages of the two years, although due regard must be paid to the small number of females used in the experiments. In the same way, a difference can also be noted in the number of eggs laid in a given time. Thus the average daily number of eggs was 6.1 (varying from 4.9 to 8.9) in 1954 and 5.2 (varying from 2.5 to 8.2) in 1955, while the greatest number of eggs was 25 in 1954 and 22 in 1955; the smallest number being 1 in both years. The greatest number of eggs laid within a five-day period was 75 (specimen No 4) in 1954 and 64 (specimen No 5) in 1955.

The reason for the difference in the number of eggs is the variation in the temperatures prevailing at the time of oviposition. With a rise in temperature, the number of eggs laid in a given time increased, and vice versa (Fig. 8). As the temperatures in late May and early June were, save for a few exceptions, appreciably lower in 1955 than in the previous year, the number of eggs laid in this period was correspondingly lower. Although oviposition, begun late owing to low temperatures, went on later in 1955 than in the previous year, and although owing to the high temperature, the number of eggs per day in 1955 was considerable as late as in mid-July, in contrast to the previous year, this was not sufficient to bring the total number of eggs up to the 1954 level.

Andersen (1934) has arrived at similar results in his extensive studies of *Sitona lineata* L. The average temperature of the early part of the egg-laying period is of decisive importance with regard to the total number of

eggs of the species. If it is high, the total number of eggs will be great, but the later the period of high temperatures begins, the lesser is the effect on increase in egg number.

The observations, mentioned previously, made by Detwiler (1923) and Hudson and Wood (1924) on the total as well as on the daily number of eggs of the species, agree with the results arrived at in the present study. On the other hand, the figures quoted by Underhill (1924) are considerably lower.

For the sake of comparison, it may be mentioned that the number of eggs laid by *Phytonomus variabilis* Herbst., a close relative to the lesser clover leaf weevil, is considerably greater; according to Kaufmann (1939), it is usually 600—700 (maximum 1525).

d. Egg-laying period

According to Webster (1909), the egg-laying period of the species is some 6 weeks. Detwiler (1923) reports the egg-laying period of two specimens as 43 and 48 days respectively. Hudson and Wood (1924) report that the longest period of oviposition they have observed was only 16 days.

In the tube rearings in the insectarium, the egg-laying period of different specimens in 1954 was 35—54 days, averaging 47 days (Table 3). In corresponding experiments in 1955, the egg-laying period was roughly the same, 34—56 days, averaging 46 days (Table 4). In the years in question, temperature conditions during the period of oviposition were rather dissimilar (cf. Fig. 8). This, however, had no effect on the length of the egg-laying period in the tube rearings, nor apparently did it have any effect in the field, as the period of occurrence of eggs in the actual experimental areas was approximately of the same length in both years (cf. Fig. 20, p. 37).

As will be seen, the observations made by Webster (1909) and Detwiler (1923) agree with the present study, whereas the egg-laying period (16 days) reported by Hudson and Wood (1924) seems curiously short.

e. Incubation period

Houghton (1908) reports the incubation period of the eggs as 8 days (at 60—70° F), and Webster (1909) reports it as 7—8 days. According to Detwiler (1923), the incubation period of the species is 11—21 days, averaging 18 days. Like Hudson and Wood (1924), he has noted that the incubation period is longer at the beginning of the egg-laying period than towards its end, owing to the difference in temperature. The longest incubation period reported by the latter is 26 days and the shortest 5 days. According to

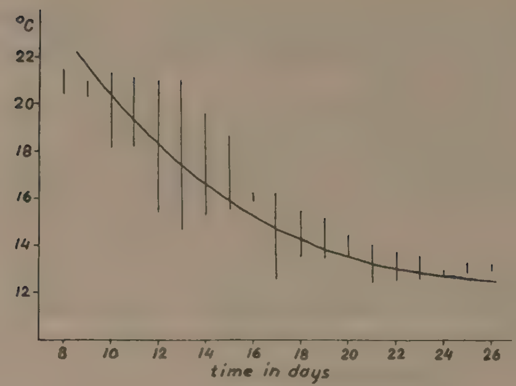


Fig. 9. The effect of temperature on the incubation period in tube rearings in the insectarium during 1954—1955. The temperature indicated is the average during the period of incubation.

UNDERHILL's (1924) investigations, the incubation period is 9—20 days, averaging 12.4 days, and according to SERVADEI (1944) it is only 7 days.

The incubation period of eggs was investigated in the tube rearings and in the actual experimental areas. In both years, the shortest incubation period was 8 days (average temperature approx. 21°C), and the longest was 19 days (approx. 14°C) in 1954 and 30 days (approx. 11.5°C) in 1955. In agreement with the observations made by DETWILER (1923) and HUDSON and WOOD (1924), the incubation period was longer in the spring and early summer than later in the summer. Its correlation with temperature is indicated in Fig. 9, which is based on observations made from the tube rearings in the insectarium, covering 262 eggs in 1954 and 640 eggs in 1955. Since the tube rearings were kept in natural conditions with constantly changing temperatures, it is understandable that there is considerable dispersion in the positions of the observation marks in the diagram. Thus it shows that the incubation period of the species is, for example, 18—21 days at 14°C and 10—14 days at 18°C.

2. *The larva*

a. Appearance and size

The general colour of the newly-hatched larva is greyish-white, with an almost black head. The reports of various investigators give the length of newly hatched larvae as between 0.9 and 1.25 mm (WEBSTER 1909, DETWILER 1923, HUDSON and WOOD 1924 and SERVADEI 1944). The mature larva (Fig. 10) is greenish or of a dirty grey colour. DETWILER (1923) reports

Fig. 10. The larva of the lesser clover leaf weevil.

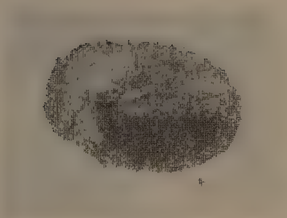


Fig. 11. The cocoon of the lesser clover leaf weevil (SERVADEI 1944).

its length as 7.5 mm and UNDERHILL (1924) gives it as 6.5 mm. — The observations made on the colour and size of both newly hatched and mature larvae agree with the figures given in literature.

According to WEBSTER (1909) and KAUFMANN (1939), the species has only three larval stages, while DETWILER (1923), UNDERHILL (1924), and HUDSON and WOOD (1924) have noted four instars. DETWILER (op. c.) also reports the measurements of the various larval stages as a basis for determining the instars.

When mature, the larva constructs a cocoon. This is made from light grey silk fibres, not very closely knitted (Fig. 11). DETWILER (1923) gives the measurements of the cocoon as 4.5 × 2.6 mm, while HUDSON and WOOD (1924) give them as 4.85 × 2.75 mm.

b. Habits

As mentioned previously, the eggs of the species are located almost exclusively in the leaflets of red clover. Soon after hatching, the larvae crawl along the petioles to seek cover in the stipules. In the tube rearings in the insectarium it was noted that, after hatching, the larvae could in some instances remain on the leaves for a few hours, perhaps even for as long as 24 hours. SCHAUFUSS (1916, p. 1093) reports that the larvae may also live as miners. This was not, however, observed in this study.

Under the conditions in our country, the young larvae usually live inside the stipules, feeding chiefly on the new shoots growing there (Fig. 12). When a larva has consumed the shoot in one stipule, it moves over to other stipules of the same plant or to another plant specimen. If the red clover bears buds at this time, the larvae may also move on to these. In fully developed

Fig. 12. The stem of a shoot growing inside a red clover stipule, badly injured by a larva. The shoot will die.

flowerheads, they usually live on the inner surface of the involucres, pressed against the head, and feeding on the nearest florets (Fig. 13). However, they also often penetrate into the head between the florets. Concealed in the stipules, the older larvae also often attack the 'main stem' of red clover, (Fig. 14), and when situated in the heads they may attack the axis of the inflorescences. Sometimes one digs itself partly or wholly into the stem, in which it may make a tunnel of a diameter slightly exceeding its own.

The larvae of the lesser clover leaf weevil do not move about much. The greatest part of their life they spend concealed in the stipules or heads and only move from their hatching places to the stipules and from there to new feeding places in the stipules or heads, and finally to seek somewhere for pupation when mature.

For food, the larvae above all seek the younger parts of their food plants. In addition, however, they must live in a sheltered part of the host plant, since they are otherwise apt to fall off. Such feeding places which fulfil these conditions are the young shoots in the shelter of the stipules and young inflorescences. A sheltered feeding place is not, however, an absolute necessity. In experiments made with white clover, it was established that the newly hatched larvae fed on already developed leaves growing out from between the stipules. The stipules of this plant do, indeed, offer the larvae practically no shelter.

Webster (1909) and Detwiler (1923) seem to think the larvae of the species feed more typically and commonly in the inflorescences than in the

Fig. 13. A larva between a red clover bud and its involucre (bent down).

crevices of the stipules. In this study, it has not been found that the larvae show a preference for either feeding place, but that they spread equally to the stipules and to the heads, if both are available.

In 1953—54, when the first inflorescence buds appeared after mid-June, the period of the greatest occurrence of larvae was already over (cf. Fig. 20, p. 37). Thus only a small number of the larvae had an opportunity of feeding on the inflorescences. The greatest incidence of inflorescences was in early July, but even then their number was less than 10 pc of the total number of larvae.

Owing to the exceptional cold early summer in 1955, the first inflorescence buds appeared on red clover a fortnight later than in the two previous years. The development of the larval stage of the lesser clover leaf weevil was even more belated. When the first larvae began to appear towards the end of June, or four weeks later than in the two previous years (cf. Fig. 20, p. 37), most larvae had an opportunity to feed on the inflorescences. Consequently in the shoot samples taken from the actual experimental areas (IV and V) on July 14th, 1955, 33 pc of the larvae were found in inflorescences. On July 20th and 26th, the corresponding figures were even higher, 63 pc and 62 pc. In the samples taken from the Espoo experimental area on July 15th, 42 pc out of 503 larvae were found in inflorescences.

Thus in different years there may be great divergences in the incidence of larvae in the stipules and in the inflorescences, depending on temperature. It seems that in years when the early part of the summer is normal in respect to temperature, a great number of the larvae in this country live in the

Fig. 14. After completely destroying a shoot growing inside a red clover stipule, the larva has also begun to feed on the main stem (SERVADEI 1944).

crevices of the stipules and only the latest larvae feed on inflorescences.

The number of larvae found simultaneously on the same shoot is governed by their overall number in the field. In a sample of 800 shoots taken from the Espoo experimental area on July 15th, 1955, comprising 503 larvae in all, 238 shoots had only one larva each, 92 shoots had two larvae each, 19 shoots three larvae each, and 65 shoots four larvae each. In another sample, also comprising 800 shoots, taken from different places between June 17th and June 25th, 1953, the number of larvae was somewhat less, viz. 456. Here, too, the shoots with only one larva formed the majority, or 333. Two larvae were found on each of 51 shoots, three larvae on each of 5 shoots and six on one shoots. Six was the greatest number found on one single shoot. In samples taken from different places, containing 20 larvae or less per 100 shoots, there usually was only one larva on each shoot.

Generally there is only one larva feeding on any one stipule or inflorescence; more rarely there are two. This was also found by WEBSTER (1909) and HERRICK and DETWILER (1919).

When mature, the larvae usually set off to find a suitable place for constructing their cocoons, but they may also do this at their last feeding place, in the crevices of the stipules or the inflorescence. According to DETWILER (1923), the construction of the cocoon takes several hours. In a case observed by *Rasinmäki* (p. dept. arch.), it was completed in about 3 hours.

According to WEBSTER (1909), the cocoons are usually situated in the inflorescences of red clover, although they may also be found on the leaves. DETWILER (1923) mentions the inflorescences as the most common location for the cocoons, although he says they may also be found in other parts of the plant, e. g., in the forks of stems. According to HUDSON and WOOD (1924), in addition to the places mentioned above, the cocoons may be situated in old and wilted clover leaves.

In observations made from the actual experimental areas, it was found that the cocoons were usually situated in the forks of stems or in the crevices of the stipules (Fig. 15). They were found almost as often in the inflorescences, particularly on the inner surface of the involucres beneath them. but also between the florets. They appeared more seldom on the leaves. In 1955, the number of cocoons found in inflorescences was relatively greater

than in the two previous years, obviously because the number of larvae in the inflorescences was also greater in 1955.

The larvae may also build their cocoons on other plants besides their food plants. In experiments to establish the choice of food plant they were found on different clover species and, in addition, on some other plants of the *Papilionaceae* family, as well as on plants belonging to certain other families. In the field, cocoons were occasionally found on weeds growing in red clover fields, and in 1953 cocoons were observed in stacked hay, not only on red clover, but also on timothy and some weeds.

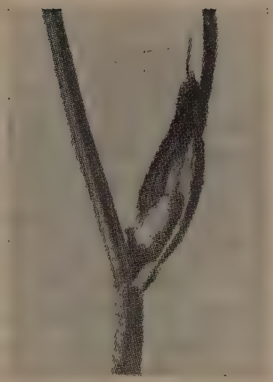


Fig. 15. Cocoon in a crevice of a red clover stipule (Servadei 1944).

c. Larval period

In literature, there is comparatively plentiful information on the larval period, but the prevailing temperatures are not indicated. According to Webster (1909) and Detwiler (1923), the larval period is 17—20 days, and according to Underhill (1924) it averages 20 days. The investigations carried out by Hudson and Wood (1924) resulted in averages of 17 days (1923) and 21 days (1924). Servadei (1944) gives the larval period as 14—20 days and in experiments made by *Rasinmäki* (p. dept. arch.) on a few specimens it was about 16 days at 19°C.

According to Webster (1909), the lengths of the various instars are as follows: I 3—7 days, II 6—7 days and III 7 days (cf. p. 23). The data supplied by Detwiler (1923), Underhill (1924) and Hudson and Wood (1924) differ only slightly and fall within the following limits: I 5—7 days, II 3—6 days, III 3—6 days and IV 5—8 days.

The duration of the larval period was studied in tube rearings in the insectarium in 1954—55. Larvae in the rearings hatched between June 27th and July 9th in 1954 (five specimens), and between June 28th and July 13th in 1955 (28 specimens). The larval period was 14—20 days, while the temperature averaged 20.4—17.1°C. Rough field observations agreed with these figures.

The time the larva spends in the cocoon before pupation is included in the larval period. This was noted as 1—3 days, in agreement with observations made by Detwiler (1923) and Underhill (1924). According to the former, the prepupal period is 2—3 days; according to the latter it is 2.03 days on the average (maximum 4 days).

3. *The pupa*

At first the pupa in the cocoon is of a light dirtyish yellow colour. In the course of the pupal period, the general colouration changes to a reddish brown. According to UNDERHILL (1924), the size of the pupa is 4 × 2 mm, and according to HUDSON and WOOD (1924) it is 4.85 × 2.01 mm.

According to WEBSTER (1909), the pupal period normally lasts about 6 days, while according to DETWILER (1923) it last 5—8 days. HERRICK and DETWILER (1919), as well as SERVADEI (1944), state it to be much longer, 13—16 days. According to observations made by UNDERHILL (1924), the pupal period averages 8.5 days (max. 16 days, min. 6 days). Information on temperatures is lacking. In experiments carried out in a cool basement room, *Rasinmäki* (p. dept. arch.) has determined the length of the pupal period of the species to be 14—16 days.

The pupal period of the species was studied in tube rearings in the insectarium in 1955. The 23 specimens in the rearings, of which the majority were similar to those investigated during their larval period, were encased between July 14th and August 1st. The pupal period varied from 10 to 18 days, and the average respective temperatures were 18.6°—16.6°C. Rough observations made in field experiments led to corresponding results.

4. *The adult*

a. Appearance and size

Fig. 16. Adult lesser clover leaf weevil, about one month after emerging from its pupal cell.

The young adult weevil is brown. Gradually the dorsal part darkens, and within about a week the adult is dark grey, or often clearly green (Fig. 16). It remains so till autumn. In the spring, after hibernation, it is greyer and has clearly lost its bright green colouration. During the summer, it loses the green colour completely and is dark grey in late summer and autumn.

According to DETWILER (1923) and HUDSON and WOOD (1924), the adult is 3.7 mm long, its width being just under half its length. SERVADEI (1944) gives its length as 3—4 mm, but, according to SCHAUFUSS (1916 p. 1095), the adult is rather bigger, 3.8—4.5 mm long. The specimens measured by UNDERHILL (1924) have also been fairly long (3.5—4.5 mm). Of the 33 specimens measured in this study, the smallest had a length of 3.1 mm and a width of 1.5 mm, while the length of the largest was 4.0 mm, and its width 1.9 mm. The average

Fig. 17. Adult weevil damage to red clover leaves.

length of the specimens was 3.64 mm and their average width 1.66 mm, which are clearly less than the figures quoted by SCHAUFUSS (op. c.) and UNDERHILL (op. c.).

b. Habits

According to DETWILER (1923), after their emergence the adult weevils live 2—3 days in their cocoon before moving. In the tube and cage cultivations in the insectarium, this period lasted 1—3 days. The newly-matured adult eats its cocoon, or at least part of it (HOUGHTON 1908, WEBSTER 1909 and DETWILER 1923). *Rasinmäki* (p. dept. arch.) has also made this observation. In the tube rearings in the insectarium, it was established, in agreement with the above, that the adults usually eat their cocoon, or the greater part of it. It is possible that eating of the cocoon chiefly occurs only in conditions when the young adults have to do without food for some time. This is indicated by observations made by HOUGHTON (1908), *Rasinmäki* (p. dept. arch.), and the present authors. The adult always eats an exit hole in the cocoon.

The adult lesser clover leaf weevils are well concealed, usually in the lower and middle parts of the food plant. They seem to be rather stationary. During heavy rain, they seek shelter beneath the leaves (SCHNELL 1955). When moving from one place to another, they often pause. Observations of the adult weevil are also difficult to make because it is very apt to feign death.

Owing to their living habits, the adult weevils are not easy to catch by net. This particularly applies to the hibernated adults, the numbers of which usually seem to be small (see p. 35). For this reason, it is not possible, on the basis of netting samples, to compare the relative numbers of clover weevils and, for example, *Apion* species in a field (cf. SCHNELL 1955).

The adult weevils feed chiefly on the red clover leaves, in which they usually make rectangular slits (Fig. 17). They also gouge holes in the stipules

Fig. 18. Adult weevil damage (black spots) to red clover stipules.

and stems (Fig. 18). Sometimes, but only rarely, the adult attacks the petioles. In the tube and cage rearings in the insectarium, in some cases it was found that the adult weevils had almost gouged the petiole through, so that it broke under its own weight.

According to DETWILER (1923), the species seems partly to have a second generation in a single year. DOSSE (1954) also mentions two generations. In our country, this has not been found to be the case.

The adult weevils seldom take wing and it is difficult to make them fly, even when disturbed (UNDERHILL 1924). Occasionally, however, mass flights of adults have been observed.

In 1896 in Newark (Delaware), HOUGHTON (1908) found a big swarm of adults floating in a pond. REH (1913, p. 545) mentions that adults of the *Phytonomus* family often take to massed flight in summer. The most notable instance in Finland was observed by KUKKO (1948): on May 17th, 1947, a big swarm of insects was found at Suomenlinna, Helsinki. In a sample taken, comprising some 3500 specimens, the number of lesser clover leaf weevils (1004 specimens) was exceeded only by that of *Galerucella lineola* F. (1180 specimens). According to the author, a temperature maximum prevailing a couple of days earlier had apparently caused the strong flying activity of the insects. Possibly the insects, originating from the southern coast of Finland, had been flying against the wind and thus had been driven into the water.

The adults usually hibernate in their summer biotope in red clover fields, among the stubble of red clover and old refuse, but also at the verges of ditches bordering the clover field, at the edges of the field, etc. (WEBSTER

1909, DETWILER 1923, UNDERHILL 1924, SERVADEI 1944 and SCHNELL 1955). — Observations made in the course of this study agree with literature. In our country, the majority of the adults usually seem to retire into hibernation towards the end of August (see p. 42).

Copulation takes place in the spring, almost immediately upon emerging from hibernation. The position for copulation is that common to weevils. In a case observed by *Hukkinen* (p. dept. arch.), copulation lasted for 3 hours 15 minutes, and in a case observed in this study, the duration was 3 hours 45 minutes.

The adult weevils live for about one year. In this country, they emerge in July/August, and apparently most females die at the same time the following year, i. e., soon after the egg-laying period. Both in 1954 and 1955 some of the hibernated females were found to have lived until October/November at least, or 15—16 months. Males usually do not live much longer than one year. KAUFMANN (1939) has arrived at roughly similar conclusions with regard to the length of life of *Phytonomus variabilis* Herbst.

5. *Duration of the complete development*

WEBSTER (1909) mentions that the adults emerge some 32 days after oviposition, while DETWILER (1923) mentions that they appear after 35—52 days. These authors do not indicate the prevailing temperatures.

In the tube rearings in the insectarium, kept at natural temperatures, the duration of the various developmental stages was as follows: egg period 8—32 days, larval period 14—20 days, and pupal period 10—16 days. The life history from new-laid egg to adult thus takes 32—68 days.

Information on the duration of the complete development was also obtained from the actual experimental areas, on the basis of netting and shoot samples. Going by the first eggs observed in the actual trial areas, and the first incidence of adults (see Fig. 20, p. 37), the following table regarding the full development period results:

Year of observation	Date of first eggs	Date of first adults	Total developmental period, days	Average temperature during developmental period, °C
1953	19. 5	12. 7	54	15.2
1954	20. 5	14. 7	55	15.2
1955	28. 5	29. 7	62	14.4

In 1953—54, the total developmental periods of specimens originating from first eggs, as well as the average temperatures during this time, were practically identical. In 1955, the average temperature at the time of the

development of the first specimens was 0,8°C lower than in the two previous years, and consequently the total developmental period longer by 7—8 days.

In any one year, the development of the specimens from the first eggs usually takes place at lower temperatures than that of later specimens. The developmental periods quoted in the table above are probably the longest in the years under reference. The development of adults from eggs laid later was considerably more rapid in each year. For example, eggs laid on June 24th, 1954, developed into adults in 45 days (average temperature 16.4°C), and eggs laid on June 15th, 1955, developed in 44 days (average temperature 16.6 °C).

V. Time of occurrence and abundance of the various developmental stages

In the archives of the Department of Pest Investigation, Agricultural Research Centre, there are records of nearly 100 instances of the occurrence of the lesser clover leaf weevil as a pest from the years 1911—1955. The great majority are observations made by investigators of the Department of Pest Investigation. The greatest number among these are those made by *Hukkinen* during the years 1913—1929, and those made in connection with this study in 1953—55. Cases reported by farmers on their own initiative amount to only a dozen or so.

In this country, little attention has been paid to the damage inflicted by the lesser clover leaf weevil. Owing to the living habits of the species, even occurrence in great numbers is inconspicuous. Likewise, the injuries inflicted are not easily seen, since they are mainly located inside the stipules. The damage to flower-heads is also less conspicuous than, for example, that done by members of the *Apion* genus to the seeds of clover. Obviously, however, the lesser clover leaf weevil is present every year in great numbers in the majority of red clover fields in Southern and Central Finland, and it is an important pest. This conclusion can be drawn from the collected information in the archives of the Department of Pest Investigation, and from the observations made in different places in connection with this study.

1. *Effect of temperature during season of growth*

The following facts may be cited regarding temperature conditions during the summers affected by this investigation: in 1953, the mean temperature of each month from May to August was above normal. The difference in this respect was biggest in June. In 1954 also, each month from May to August was warmer than normal. May was considerably warmer than in the previous year, while June was cooler by at least as much. Whereas the years 1953—54 were roughly equivalent as to temperature, 1955 differed greatly. May and June were decidedly cooler than normal, particularly the former with its average temperature of almost 5°C below that of May 1954. During

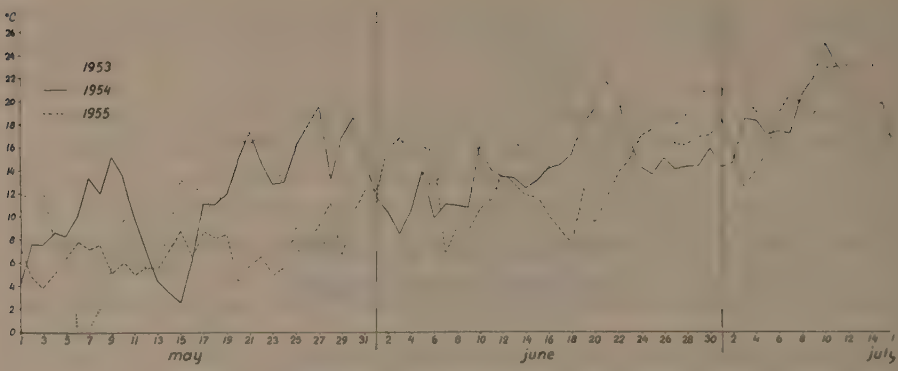


Fig. 19. Daily mean temperature at the Agricultural Research

these months, plant growth was 2—3 weeks behind normal. On the other hand, July and August were considerably warmer than normal, and even decidedly warmer than in the two previous years. Fig. 19 shows the daily mean temperatures during these summers, and the table below gives the monthly averages, as well as the normal mean temperatures at the Agricultural Research Centre, Tikkurila, during 1901—1930.

Mean temperature, °C.

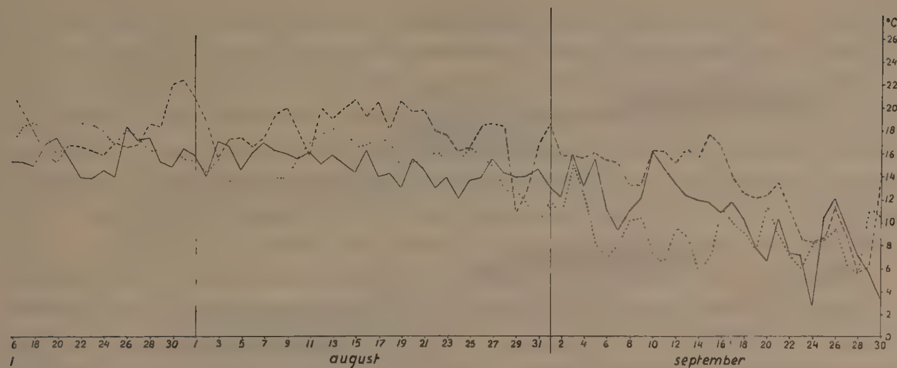
	1953	1954	1955	Norm.
May	9.2	11.2	6.3	8.3
June	15.9	13.7	11.9	12.7
July	16.8	16.8	17.9	16.0
August	15.1	15.0	17.9	13.5

a. Hibernated adults

The majority of the adult weevils hibernate in their summer biotope, the red clover field (see p. 30). According to Webster (1909) and Detwiler (1923), they leave their places of hibernation in early spring, when the clover has begun to grow well.

The first adult specimen in the year 1954 was observed on May 5th. Two days later, the first few minor injuries were found on the leaves. The tallest red clover specimens were then about 5—7 cm high, measured from the base of the stem to the tip of the leaves. On that day also, the first two specimens were netted (in experimental area I). By May 14th, the leaf injuries were much more evident, although still not common.

In 1955, the tallest red clover specimens reached a height of 5 cm as late as May 23rd. In the leaves, feeding punctures made by *Apion* species, but



Centre, Tikkurila, during May-September 1953, 1954 and 1955.

not by the lesser clover leaf weevil, were found. On May 26th a netting sample taken from a red clover field at Fiskars contained one adult. Only on May 28th were they found in the actual trial areas as well. Careful examination also revealed some feeding traces on red clover.

In 1955, the adults left also left their places of hibernation about three weeks later than in the previous year. This great difference between the two years is due to the considerable difference in temperature. In 1955, in the whole of May the daily mean temperature did not rise as high as it was on May 7th in 1954, namely 13.3°C. May 28th, which was the warmest May day so far in 1955, and on which the first specimens were netted, had an average temperature of 11.3°C (Fig. 19.). — According to KAUFMANN (1939), *Phytonomus variabilis* Herbst. leaves its place of hibernation when the temperature reaches 8—10°C.

From the aforesaid, it may be concluded that, in Southern Finland, the adults usually emerge from hibernation and the first feeding traces appear when the red clover is about 5 cm high. This probably occurs, on the average, in mid-May or shortly afterwards. On exceptionally warm days, however, adults may, at least temporarily, emerge much earlier, perhaps in April.

Rasinmäki (p. dept. arch.) has observed that netting samples contain only a few hibernated adults. In 1953—54 about half of the netting samples taken in the actual experimental areas contained no adults. The other half contained 1—2 specimens. In samples taken from other places, the number of adults was equally small. In 1955, the netting samples clearly contained more hibernated adults. Their number was greatest in samples taken on June 21st and July 6th, the former yielding 14 specimens from experimental area IV and 5 specimens from experimental area V, the latter giving 10 and 6 specimens respectively from the same experimental areas. Other netting samples yielded 5 adults at a time, at the most, and three times none

at all. — In the Espoo experimental area, netting samples taken from 14 different experimental squares contained three adults on the average.

The number of hibernated adults showed no decrease before the emergence of the new generation in the middle or at the end of July. After this, netting samples no longer contained hibernated specimens. In breeding trials conducted in the insectarium, some of the adults were found to die soon after the end of the egg-laying period in August, while others lived until October or even November, as mentioned before (p. 31).

Whereas the number of hibernated specimens was rather low, netting samples contained many more adults of the new generation, usually some dozens. In 1953, netting samples taken in experimental area I yielded 40—50 specimens of adults of the new generation when their number was at its highest. In the following year, after hibernation, two specimens was the maximum, but often there were none. In 1954, the richest yield from a netting sample taken in experimental area IV was more than 80 adults of the new generation, and in experimental area V it was over 60. After hibernation, the maximum number of adults was 14 specimens in the former area and 6 specimens in the latter. Whether the significant decrease in the number of adults during hibernation is due to their destruction during the winter, or, for instance, to migration elswhere, cannot be established on the basis of the experiments conducted.

b. Eggs

The females are mature for oviposition early in the spring, but they begin laying eggs only when the temperature has risen high enough. According to observations made by *Hukkinen* (p. dept. arch.), females collected from their places of hibernation (red clover stubble) on April 20th, 1921, began oviposition when taken to the warm laboratory on the same day. An adult found in experimental area I A on May 5th, 1954, deposited 7 eggs in the laboratory only one day later, although the first eggs did not appear in the field until a fortnight afterwards.

In 1954, females in tube rearings in the insectarium laid their first eggs on May 20th (Table 3, p. 19). In the field also, the first eggs were observed on the same day (Fig. 20). The daily mean temperature on May 20th was 15.0°C (Fig. 19).

In 1955, owing to the lower temperature, the females laid their first eggs in the tube rearings in the insectarium 8 days later than in the previous year, or on May 28th (Table 4, p. 19). In that year, too, the first eggs were found in the field on the same day as in the insectarium. May 28th was the warmest day of the month so far, with an average temperature of 11.2°C (Fig. 19).

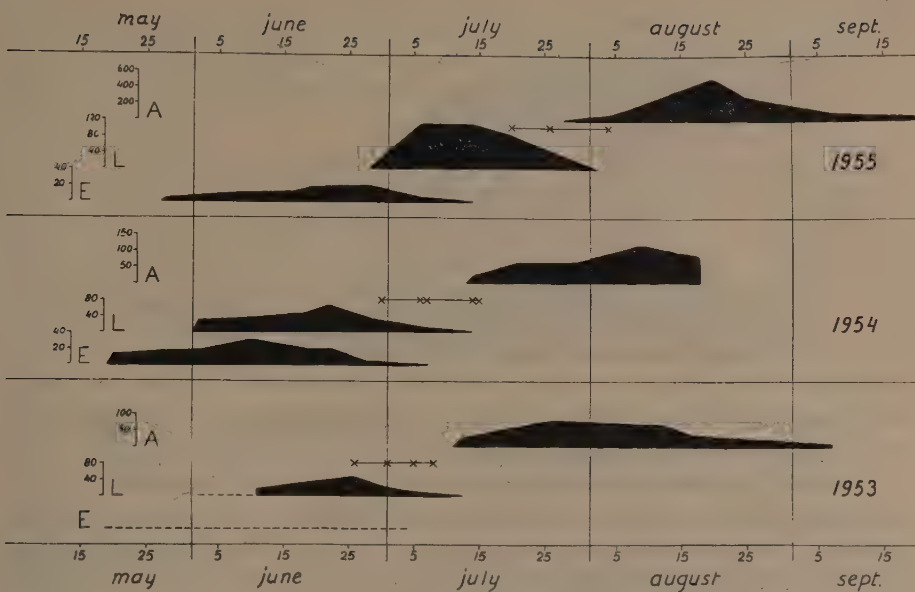


Fig. 20. Time of occurrence and abundance of the various developmental stages in the actual experimental areas at Tikkurila in 1953—55, on the basis of 100 shoot samples and 100 double netting sweeps taken from each experimental area. The experimental areas numbered two each year: in 1953 experimental areas I and II, in 1954 experimental areas IA and III, and in 1955 experimental areas IV and V (see pp. 8—9). The probable time of occurrence of eggs and larvae in 1953 is marked by a dotted line.

E = eggs, L = larvae, A = adults of new generation, cross (×) = pupae found.

In 1953 no detailed observations were made, but on the basis of what was found in 1954—55 regarding the dependence of the beginning of oviposition on temperature and its relation to the time when the larvae emerge, it may be considered probable that oviposition began during the peak temperatures on May 19th—23rd, presumably on the 19th (Fig. 19).

In the tube rearings in the insectarium in 1954, oviposition decreased sharply during the last week of June, although the last day of egg-laying of the latest specimen was July 20th (see Table 3, p. 19). In shoot samples taken from actual experimental areas, the last eggs were found on July 6th (Fig. 20). Apparently, even after this time there were some eggs in the undermost, already wilted leaves of red clover, which were not included in the shoot samples. In any case, eggs had become very scarce in the field by early July.

In 1955, oviposition of the females only decreased significantly in the tube rearings towards mid-July. The last day of egg-laying was 8 days later than in the previous year, as was the beginning of oviposition, too. Likewise, in 1955 eggs were found in the actual experimental areas somewhat later

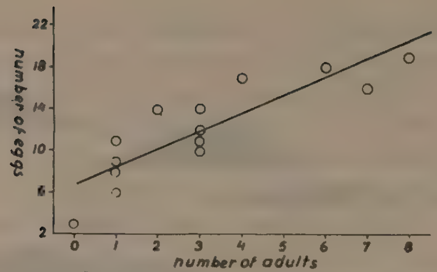


Fig. 21. The correspondence between hibernated adults and the occurrence of eggs. The number of hibernated adults in samples of 100 double net sweeps, and the number of eggs in samples of 50 shoots from 14 experimental squares of 10 ares each in the Espoo experimental area.

than the year before. In both years, the period during which eggs were found lasted about 1½ months (Fig. 20).

In 1954, the number of eggs reached a peak around June 10th, and in 1955 the peak was reached only towards the end of June (Fig. 20). On the average, 100 shoot samples contained some 10 eggs. The greatest number in the actual experimental areas was 20.

In the southern parts of Finland, eggs of the lesser clover leaf weevil are probably generally founds from the latter half of May until the beginning of July, with the peak in mid-June.

The correspondence between the number of hibernated adults and the number of eggs, was established by investigations carried out in the Espoo experimental area in the summer of 1955. From each of 14 experimental squares of 10 ares, samples of 50 shoots and 100 double net sweeps were taken on June 17th. For example, from experimental squares yielding only one adult in the netting samples, the shoot samples contained 6—11 eggs, whereas in experimental squares yielding 6—8 adults, 15—19 eggs were found (Fig. 21). Thus the quantity of adults in the netting samples corresponds well to that of eggs found in the shoot samples.

c. Larvae

According to data in the archives of the Department of Pest Investigation, the earliest date on which larvae have been found is June 6th (at Kuhmoinen in 1920). The latest date is August 4th (at Pori in 1922). The majority of observations have been made at the end of June and in July.

In 1953, the first shoot samples were taken from the actual experimental areas on June 10th. The number of larvae concealed in the stipules was then already considerable. On the basis of the size of the larvae and the prevailing temperatures, it can be concluded that the first larvae hatched in the field during the first few days of June, probably on June 2nd.

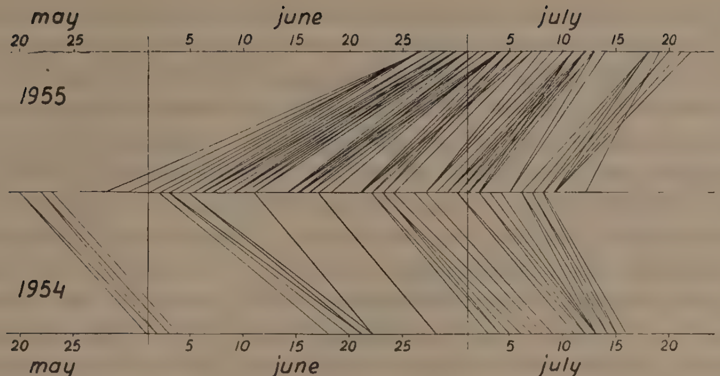


Fig. 22. The incubation period of eggs laid at different times in the tube rearings in the insectarium in 1954—55. The days of oviposition (on the central horizontal line) are linked up by oblique lines with the hatching days (in 1954 on the lower horizontal line, and in 1955 on the upper horizontal line).

In 1954, the first larvae in the tube rearings in the insectarium were hatched on June 1st. In the actual experimental areas, the first larvae were collected one day later. From their size, it was concluded that some had hatched on the previous day at least, viz. June 1st, if not a day before that.

In 1955 the first larvae in the tube rearings in the insectarium were hatched as late as June 27th. The shoot samples collected from the actual experimental areas on June 28th contained no larvae, but samples taken 8 days later already contained great numbers. Since some of these were then more than 3 mm in length, the longest being 3.7 mm, they had apparently been hatched on June 29th.

Thus in 1955 the first larvae appeared about four weeks later than in the two preceding years. This resulted from the considerably lower temperatures of May and June 1955, which delayed the development of the eggs. In the tube rearings in the insectarium, the incubation period of the first eggs was 12 days only (20th May—1st June) in 1954 and 30 days (28th May—27th June) in 1955. The incubation periods of eggs laid later did not show such great differences. Thus eggs laid on June 2nd were hatched in 16 days in 1954, and in 25 days in 1955. The incubation period of eggs laid towards the end of June and in July was roughly of the same length in each year (Fig. 22). In 1953—1954, the last larvae were encountered in the actual experimental areas shortly before the middle of July. In separate observations, occasional larvae were also found in the trial fields after mid-July. Thus, in the years under reference, the period of occurrence of the larvae in the field was some 1½ months (Fig. 20, p. 37).

In 1955, larvae were found in the field right up to the end of July. The period of their occurrence was only about one month, or 2 weeks shorter than in the two previous years. This was due to the fact that in 1955 the larvae were hatched within a shorter period, and, in addition, the hot weather in July accelerated their development (Fig. 22, p. 39).

In 1953—1954, the number of larvae was at its highest towards the end of June. The following samples of 100 shoots contained the greatest number of larvae: in 1953, from experimental area I on June 25th, 36 larvae; and in 1954, from the same experimental area (IA) on June 22nd, 44 larvae. In 1955, the peak occurred shortly before the middle of July. The richest samples were collected in experimental area IV on July 6th and 14th, yielding 59 and 60 larvae respectively. — In other places, observations indicated that the larvae were to some extent more abundant than at Tikkurila. For example, in a sample of 800 shoots taken from the Espoo experimental area on July 15th, 1955, there were 63 larvae per 100 shoots on the average.

In the southern parts of Finland, larvae of the lesser clover leaf weevil generally seem to occur from early June until mid-July. The peak is probably reached in the latter half of June.

d. Pupae

In 1953—54, pupae were found in the field from late June to mid-July; owing to the higher temperature in June, they were found somewhat earlier in the first year than in the second. In 1955, the pupae occurred about three weeks later (Fig. 20, p. 37). Whereas in 1955 the first larvae were some four weeks late in comparison with the two previous years, due to the warm July, this delay was reduced by one week with respect to the pupae. — In the southern parts of Finland, pupae probably usually occur between the beginning and middle part of July.

In shoot samples taken from the actual experimental areas, the number of pupae was usually comparatively small in relation to that of larvae, being 10 or less. The small number of pupae was apparently due, in addition to the destruction of the larvae, to the fact that they were located on the undermost leaves of red clover, which, particularly in the later developmental stages of the plant, were only to a small extent included in the shoot samples (cf. p. 37). In addition, there were pupae on wilted red clover leaves and even on weeds, although not in very great numbers. — Owing to their habits of life, almost all larvae, on the other hand, were comprised in the shoot samples.

e. Adults of the new generation

In 1953, the first adults of the new generation were found in netting samples taken in the actual experimental areas on July 12th, and in the following year two days later, on July 14th. In 1955, the first adults appeared on July 29th. Thus the delay in comparison with the two preceding years was a good fortnight with regard to adults. — In 1929, *Rasinmäki* (p. dept. arch.) collected the first adults of the new generation by netting on July 24th, but the majority of them, he reports, appeared in early August.

In 1953, the occurrence of adults reached a peak towards the end of July and in early August. Most specimens (58) were gathered in experimental area I on July 26th by netting. The last netting samples were taken on September 7th, when a total of 10 adults were collected from experimental areas I and II. At the end of August, the number of specimens in the netting samples was already small, the adults having begun to retreat into hibernation.

In 1954, the adults were most abundant early in August. The greatest number (87 specimens) were netted in experimental area III on August 9th. The next samples, taken on August 18th, still contained many adults, but on August 25th there were none. Owing to continuous rain, no further samples were taken. The majority of the specimens probably retreated into hibernation soon after mid-August, apparently because of the heavy rains and the lower temperature as compared with the two other years under review.

In 1955, the number of adults of the new generation reached a peak as late as around August 20th. On that day, netting samples from experimental area IV yielded the most adults (279 specimens). On August 25th the number of specimens was reduced, although it was still considerably greater than in the previous years (experimental area IV, 164 specimens). In early September, the netting samples yielded only a few adults, but nevertheless a netting sample taken from experimental area V as late as October 19th, contained 8 specimens. The majority of the specimens in 1955 retreated into hibernation at the end of August/beginning of September, i. e., somewhat later than in the two previous years (Fig. 20, p. 37). — In experiments on choice of food plant, it was found that the feeding of adults decreased considerably around August 25th. In the tube rearings in the insectarium, where some of the hibernated adults were alive in October and even in November, neither they nor the adults of the new generation fed practically at all in September. Only a few very small feeding marks appeared on the host plants.

In the Espoo experimental area, the adults of the new generation numbered a little more than in the actual experimental areas at Tikkurila, as was also the case with the larvae (p. 40). Netting samples taken from all

14 experimental squares on August 11th contained 183 adults on the average. The greatest number of specimens in any one netting sample was 320.

The adults of the new generation usually appear in Southern Finland in mid-July or soon after. They begin to retire into hibernation as early as mid-August, and by early September only a few adults are still active. -- *Phytonomus variabilis* Herbst. also begins to retire into hibernation in the summer (Kaufmann 1939).

2. *On the effect of some other factors*

The great influence of temperature conditions during the developmental period at the time of occurrence of the various stages has been noted above. Since the last of the summers under investigation (1955) differed greatly from the two previous summers (1953, 1954), which were rather similar to one another, the influence of temperature was particularly clearly discernible. The summers also differed greatly with respect to rainfall. The developmental periods in 1953—54 were, from the end of June, exceptionally rainy at times, while June, July and August of 1955 were exceptionally dry. If precipitation and humidity in general have great influence on the species, it should have been established during the vastly different conditions prevailing during these years. However, no clear effect could be noticed. The heavy rains in August 1954 probably contributed to the comparatively early hibernation of the species. — According to Schnell (1955), the direct effect of rain on *Phytonomus* and *Sitona* species living on leguminous plants is probably insignificant.

The numbers in which the lesser clover leaf weevil occurs are greatly dependent on the plant species. In Finland, the weevil occurs in great numbers only on red clover. Among the leguminous field plants, alsike clover also accommodates all developmental stages in this country, although in small numbers compared with red clover (see p. 53). On white clover, no developmental stages save adults were found in the field, but in rearing trials in the insectarium the species developed from egg to adult (p. 53). On other leguminous grassland plants, adults alone are found in this country, and even they occur only occasionally. Among wild plants of the *Papilionaceae* family, zigzag clover (*Trifolium medium* L., Huds.) harbours the various developmental stages of the lesser clover leaf weevil in considerable numbers.

The plant species also has some influence on the time of occurrence of the various developmental stages. As the development of the larvae, according to observations, is slower on food plants other than red clover (see p. 53), the time of occurrence of the pupae, adults, and to some extent the larvae as well, is somewhat later on these, although the difference is only slight.

Apart from the actual plant species, the species composition of the field is also of significance. All developmental stages of the lesser clover leaf weevil were found in pure red clover fields, as well as in fields of red and alsike clover, red clover and timothy, and in pure alsike clover fields. Apparently the weed content of the field also has some significance. In this connection, it may be mentioned that, according to SCHNELL's (1955) studies in Schleswig-Holstein, the number of specimens of the *Apion* genus, particularly *A. assimile* Kirb. and *A. apricans* Herbst., was considerably greater in pure red clover fields than in mixed fields, although generally smaller than the number of weevil species.

The actual trial areas where the field investigations were chiefly carried out, were all first or second year fields. However, even in these the influence of the age of the field was clearly discernible. In 1953, in experimental area I (first year field), the number of weevil specimens was, judging from shoot samples, somewhat lesser than in the same field the following year (experimental area IA). A similar difference could also be observed in experimental area II in 1953—54. As experimental areas IV and V were second year fields in 1955, the number of specimens was considerably greater than in the previous year. Thus the number of hibernated adults was two or three times greater, according to netting samples.

In observations made in some locations, it was found that the species was also rather abundant in third year fields, or even in older ones. Thus samples of 100 shoots each, taken at Säkylä on July 17th, 1953, yielded 65 and 70 larvae from two second year fields, and 80 larvae from a fifth year field. *Hukkinen* (p. dept. arch.) reports that he observed very severe damage in a third and a fourth year field at Kuhmoinen on July 22nd, 1928, whereas there was virtually no damage in a first year field.

The numbers of the lesser clover leaf weevil per area unit diminish as the field grows older and the red clover simultaneously becomes sparser. In a first year field, however, the number of specimens will not be great, despite a dense growth of red clover. The adults move over to the plants chiefly in the spring or early summer. Thus egg-laying begins, on the average, a little later in first year fields than in older fields where the adults have hibernated.

The number of weevils per area unit is, according to observations, at a peak in second and third year fields. The proportionally greatest damage is, however, generally inflicted in older fields, because in the sparse growth the weevils have gathered in large numbers on the remaining red clover specimens. Usually several larvae are then found on each red clover specimen. — In his observations in Schleswig-Holstein, SCHNELL (1955) found that in red clover fields ranging from 1 to 3 years of age, the number of species and individual weevils was at its greatest in the younger fields.

H a y m a k i n g also has an effect on the numbers of the species. Of particular significance is the actual time of haymaking. If mowing is done relatively late, with the red clover in flower, the larval period is usually over (Fig. 20, p. 37), and therefore the larvae will not be destroyed. The majority of the adults will have emerged from their pupal cells before the hay is removed for winter storage.

If, on the other hand, the red clover is cut before it begins to flower, the number of larvae is still at its greatest, although they will usually have attained a large size. In 1953, investigations were made to determine whether, in this case, the larvae can avoid destruction. On June 27th, just before the flowering time of red clover, part of experimental area II was mowed. Nine large-sized larvae collected from a shoot sample before mowing, were placed in a glass batiste bag on red clover shoots, and this was put among the stacked red clover hay. The two smallest larvae (3.5 and 4.5 mm) died when their food dried, but the others developed into adults. This shows that even if the hay is made shortly before flowering time, a considerable part of the larvae can survive by pupating on the stacked hay. *Rasinmäki* (p. dept. arch.) has observed that large-sized larvae are able to pupate under similar conditions. The larvae which fall on to the stubble field when the hay is made also usually seem to avoid starvation, since the bigger ones at least are able to feed on the food that is available. On the basis of the above, it seems, therefore, that haymaking shortly before the flowering time of red clover has only a slight influence on the numbers of the species. — Previously, early haymaking was thought to be a method of control of the pest, but in actual fact it is not likely to have much effect (cf. Lehmann and Klinkowski 1942).

When red clover is mowed at an early stage of growth, 2—3 weeks before flowering, and immediately removed, e. g., for silage or fodder, most larvae will be destroyed. A number of eggs and larvae will probably remain on the plants dropped on the ground, but apparently most of them die for lack of food. Thus only mowing at an early stage in the growth of red clover, before the heads have developed, has a perceptible effect in reducing the numbers of the species.

Among the n a t u r a l e n e m i e s of the lesser clover leaf weevil, parasite insects are the most important. The greatest significance seems to be attributed to a small ichneumnide, *Candiella (Bathyplectes) exiqua* Grav. (Detwiler 1923, Chamberlin 1933 and Lehmann and Klinkowski 1942). It pupates in the cocoon of the lesser clover leaf weevil. It is obviously the same species that *Hukkinen* and *Rasinmäki* (p. dep.t arch.) reported as a common parasite on the lesser clover leaf weevil in this country, and the pupae of which were found not infrequently inside the cocoon of the lesser clover leaf weevil in connection with this study. Other insect parasites

mentioned are *Dibrachoides dynastes* Först. (Rockwood 1920 and Chamberlin 1933), *Microbracon* sp. (Detwiler 1923 and Lehmann and Klinkowski 1942), *M. mellitor* Say (Underhill 1924), *M. tenuiceps* (Muesebeck 1925), *Bracon sp.* (Webster 1909 and Lehmann and Klinkowski 1942), *Anisia sp.* (Webster 1909), *Diplazon albicinctus* Ashm. and *Spilochalcis sp.* (Underhill 1924), and *Perilitus aethiops* Nees (Kaufmann 1939). *Anaphes iole* Girault (Underhill 1924) is parasitic on the eggs. Among birds, the starling has been found to feed on adults of the species in the north-eastern states of North America (Kalmbach and Gabrielsson 1921).

Among fungi, *Entomophthora sphaerosperma* Fres. (Webster 1909 and Lehmann and Klinkowski 1942) is reported to kill the species. Houghton (1908), Underhill (1924) and Elliot (1952), also mention fungal diseases. In Finland, *Rasinmäki* (p. dept. arch.) has noted some fungi to have killed the larvae and pupae.

VI. Behaviour with respect to food plants

The following brief summary may be given of information in literature regarding the food plants of the lesser clover leaf weevil: CAPIOMONT (1868) reports the weevil as living on *Ononis* species, particularly *O. spinosa* L. According to KALTENBACH (1874, p. 124), the food plant of the species is *Trifolium pratense* L. In addition, he mentions (p. 332) that larvae have been found in the inflorescences of *Buphthalmum salicifolium (Compositae)*. This is the only report of the lesser clover leaf weevil living on a plant other than those of the *Papilionaceae* family. Since other scientists have not subsequently confirmed the report, it seems obvious that it must have been some other weevil species. TARGIONI-TOZZETTI (1888, p. 304) mentions that the species lives on *Trifolium agrarium* L., em. Schreb and *T. arvense* L.

TITUS (1911, p. 451) lists the following food plants: *Trifolium pratense* L., *T. repens* L., *T. incarnatum* L., *T. medium* L., Huds., *T. hybridum* L. and *Medicago sativa* L. HUDSON and WOOD (1924) mention that the larvae and adults prefer red clover. According to them, the adults, but not the larvae, may also be found on *Melilotus sp.* and *Medicago sativa* L. LEHMANN and KLINKOWSKI (1942) list the same plants as TITUS (op. c.), but, in addition, they report that in its palearctic distribution area the species also develops on *Medicago*, *Melilotus* and *Vicia* species. DOSSE (1955, p. 430) also states that the lesser clover leaf weevil is located on the plants mentioned above.

SCHNELL (1955) has observed that the lesser clover leaf weevil also lives oligophagously on certain clover species, preferring red clover, but also developing and multiplying on alsike and white clover. He has further observed adult weevils on the *Vicia* family, *Medicago sativa* L. and *Ornithopus sativus* Link., in addition to the above-mentioned plants. According to him (op. c.), many species of weevil occur in fields where the plants cultivated are not food plants of the weevils in question. The reason is that perfectly pure cultivations in which only the leguminous plant sown grows never exist in practice.

The lesser clover leaf weevil is commonly known as an important red clover pest. In many publications the species is also reported to inflict damage on *Medicago sativa* (e. g. PICARD 1914, GRASSÉ 1929 and LEHMANN

and KLINKOWSKI 1942). Injuries to the bean have also been observed (CROSBY and BLAUVELT 1930 and THOMPSON and GOBLE 1946). In these cases, however, the adults have moved from mowed red clover over to the bean, which has not been the original food plant.

In Finland, the lesser clover leaf weevil has inflicted damage on red and alsike clover, more commonly on the former by far. According to observations by *Hukkinen* and *Rasinmäki* (p. dept. arch.), in this country the species in addition lives on zigzag clover.

1. *Oviposition in different plants*

In the insectarium, four experiments were carried out in 1955 to ascertain the choice of oviposition plant. These experiments were performed as cage rearings (see p. 10). The experimental plants were planted in the soil at the bottom of the cages, one specimen of each species being taken. The plants had been chosen with a view to similarity in size and stage of development (almost fully grown, just about to flower). At the beginning of the experiment, hibernated adults, netted in the actual experimental areas a couple of days previously, were placed in the cage. Experiments 1 and 2 were made between June 18th and July 6th, using 10 adults in each. Experiments 3 and 4 were carried out between June 23rd and July 5th, each with 5 adults. Table 5 shows the number of eggs found in each plant at the end of the experiment. In experiments 1 and 2, some of the eggs had already hatched and were therefore difficult to observe.

Table 5. Number of eggs laid in different plants in experiments to ascertain choice of oviposition plant (see text).

Experimental plant	Number of experiment				Total number of eggs
	1	2	3	4	
Trifolium pratense L.	17	12	29	22	80
T. hydridum L.	6	13	14	19	52
T. repens L.	9	2	5	4	20
T. medium L., Huds.	5	5	—	—	10
Lotus corniculatus L.	0	8	—	—	8
Medicago sativa L.	2	2	0	0	4
Vicia cracca L.	0	0	—	—	0
Pisum sativum L.	0	0	—	—	0

In the experiments reported above, the adults were free to choose the oviposition plant from among the several available. Table 6 shows the number of eggs in a tube experiment made in the insectarium in 1955, when two females had to spend the whole of their egg-laying period on alfalfa

Table 6. Number of eggs in alfalfa and red clover

Number of specimen	Experiment begun	Oviposition plant	June										
			8	9	10	11	12	13	14	15	16	17	18
1	7. 6.	*Medicago sativa* L. ...	0	9	4	3	—	0	0	0	0	0	0
2	»	» » »	0	7	0	2	—	0	0	0	0	0	3
3	»	*Trifolium pratense* L. .	5	6	4	5	—	14	3	7	5	3	5
4	11. 6	» » » .					—	4	2	3	2	1	0

and two females spent it on red clover. The specimens had been netted among red clover.

During the first days of the experiment, the females living on alfalfa laid almost as many eggs as those living on red clover, but later on they laid considerably fewer and then mostly only on days with a relatively high temperature. — It may be mentioned that on alfalfa also, both females were alive as late as at the end of October.

On June 29th, 1955, a female placed on bird's foot trefoil in a tube rearing laid only 5 eggs in all. Although oviposition of the species was at that time greatly reduced, specimens living on red clover laid considerably more eggs (see Table 4, p. 19).

In 1954, corresponding trials were made in bag rearings. Observations of these were made during the course of 4—7 days only. In the experiments, egg-laying in red, alsike and white clover was extensive and no substantial differences could be noted in the number of eggs. Considerably fewer eggs appeared in alfalfa and bird's foot trefoil. Specimens placed on chickweed *(Stellaria media* (L.) Vill.) and dandelion *(Taraxacum vulgare* (Lam.), Schrk, coll.) laid no eggs at all.

On the basis of the experiments, it can be established that, in conditions allowing the adults free choice between clover varieties and some other plants of the *Papilionaceae* family for oviposition, they clearly preferred red clover. Egg-laying in other clover species — alsike, white and zigzag clover — was also fairly frequent. In alfalfa and bird's foot trefoil very few eggs appeared. In other species of the *Papilionaceae* family *(Vicia cracca*, *Pisum sativum* and *Lupinus polyphyllus)*, there were no eggs.

In the field, the eggs were by far the greatest in number in red clover, but they were also found in alsike and zigzag clover. In white clover, alfalfa and bird's foot trefoil no eggs were found, but only small experimental squares were under observation.

In the experiments related above, observations were also made on the location of eggs. It has already been reported (p. 16) that the species generally lays its eggs under the epidermis of the lower, rather than the upper, surface of the leaflets in red clover.

in the tube rearings in the insectarium in 1955.

												July									Total number of eggs
19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	
—	0	0	0	0	1	—	0	6	0	5	3	0	3	—	0	0	0	0	0	0	34
—	4	3	0	3	0	—	0	1	0	0	0	0	0	—	0	0	0	0	0	0	23
—	5	0	0	0	2	—	11	2	0	2	4	1	1	—	0	0	1	3	1	0	90
—	8	4	4	5	8	—	11	4	0	0	0	11	5	—	11	3	0	3	0	0	89

In alsike and white clover, as well as in alfalfa, only 5 pc of the eggs on the average were located under the epidermis of the upper surface, and in red clover 25 pc were found there (Table 7).

Table 7. Number of eggs under the epidermis of the upper and lower surfaces of the leaves of various plants in tube and bag rearings in the insectarium in 1955.

Oviposition plant	Eggs upper surface		Eggs under surface		Total number of eggs
	Number	%	Number	%	
Trifolium hybridum L.	2	4	45	96	47
T. repens L.	0	0	20	100	20
Medicago sativa L.	4	7	56	93	60
Total of above	6	5	121	95	127
T. pratense L.	67	26	192	74	259

In addition to the eggs in the leaves, which are included in the table, 5 eggs were found in the stipules of alsike clover, and one in the petiole of alfalfa. The species very seldom lays eggs in these places, even in red clover (cf. p. 16).

2. *Feeding on various plants*

a. Larvae

The feeding of the larvae on various plants was investigated in the rearing cages. In experiment 1, one specimen was taken of each of the plant species mentioned below, and they were all planted in a circle. The plants were chosen with a view to obtaining the closest possible similarity as to size (15—20 cm) and stage of development (flowering about to begin or already begun). On July 9th, 1954, 10 larvae of 4—6 mm length were placed in the centre of the circle of plants, at a distance of 10 cm from each plant. An examination was made after 10 days, when the feeding marks on the plants were noted. All the larvae had pupated by this time. The results

of the examination are tabulated below. The degree of feeding is indicated as in Table 8, p. 51.

Trifolium pratense L.	++++	*Medicago sativa* L.	(+)
T. hybridum L.	+++	*Lotus corniculatus* L.	(+)
T. repens L.	+++	*Vicia sativa* L.	—
T. medium L., Huds.	++	*Lupinus polyphyllus* Lindl.	—

In experiment 2, a red clover specimen was planted in the middle of the cage, and at a distance of some 10 cm from it the plants mentioned below were planted in a circle. These latter were similar to those used in the first experiment in regard to size and stage of development. On each plant in the circle, but not on the red clover, two larvae measuring some 5 mm in length were placed. The duration of the experiment was as in experiment 1. Results:

Trifolium pratense L.	+++	*Lupinus polyphyllus* Lindl.	—
Lotus corniculatus L.	(+)	*Chenopodium album* L.	—
Vicia sativa L.	(+)		

At the very beginning of the experiment, the larvae moved over to the red clover plant, on which all the pupae were found.

In 1954, a cage experiment was carried out using as trial plants red, alsike and white clover, alfalfa, bird's foot trefoil and meadow vetchling. The experiment was continued until the larvae had consumed the red clover almost totally and the alsike and white clover to a very great extent. When running out of food, they also fed to a considerable extent on alfalfa and bird's foot trefoil, but feeding marks were not found on meadow vetchling.

On the basis of these experiments, it can be established that in conditions allowing the larvae a choice between clover species and some other plants of the *Papilionaceae* family, they clearly preferred red clover. Feeding on other clover species — alsike, white and zigzag clover — was also extensive. In alfalfa and bird's foot trefoil only a few feeding marks appeared. However, when there was a lack of food, the larvae fed to a considerable extent on these plants, too. The common vetch also showed a few slight feeding marks. On the other hand, the three other plants under investigation (*Lupinus polyphyllus*, *Lathyrus pratensis* and *Chenopodium album*), were not attacked at all.

In the field, apart from appearing on red clover, larvae were also found on alsike and zigzag clover. In all these plants they fed chiefly on young shoots developing in the stipules.

b. Adults

The feeding of adult weevils on various plants was studied in three bowl experiments in the insectarium in 1955. Ten weevils of the new generation, collected by netting from the actual experimental areas, were placed in each of round glass bowls (diameter of bottom 10 cm, height 4.5 cm, lid of glass batiste), and for food one leaf from each of the 6 plants mentioned in Table 8 was given. Each experiment comprised two bowls with the same combination of plants. Experiment 1 was begun on August 11th and examined after 24 hours. In experiment 2, begun on August 12th and also examined after 24 hours, the same weevil specimens were used. For experiment 3, new adults were taken. It was begun on August 25th and examined after 2 days. Table 8 shows the results of all three experiments.

Table 8. Feeding of the adults on various plant species in three experiments carried out in glass bowls in the insectarium in 1955. Legend: ++++ extremely numerous feeding marks, +++ numerous feeding marks, ++ fairly numerous feeding marks, + slight feeding marks, (+) only a few feeding marks, — no feeding marks (see Fig. 23, p. 52).

Combination of experiment plants	Experiment plant	Experiment 1		Experiment 2		Experiment 3	
		bowl 1	bowl 2	bowl 1	bowl 2	bowl 1	bowl 2
I	*Trifolium pratense* L.	+++	++++	+++	+++	++	+
	T. hybridum L.	++	++	+	+	+	+
	T. repens L.	++	+	+++	++	++	(+)
	Medicago sativa L.	(+)	(+)	(+)	(+)	(+)	(+)
II	*Trifolium pratense* L.	++++	++++	++++	++++	++	+
	T. hybridum L.	++	++	++	++	+	+
	T. repens L.	+++	+	++	++	(+)	—
	Pisum sativum L.	—	—	—	—	—	—
III	*Trifolium pratense* L.	+++	+++	+++	++++	++	(+)
	T. medium L., Huds.	++	+++	++	++	++	(+)
	Medicago sativa L.	(+)	(+)	(+)	(+)	(+)	(+)

In the same year, experiments were also carried out in the rearing cages, in which one individual of each of the plant species specified in the table below were planted. Young plants of similar size and stage of development were chosen. The experiment was begun on August 23rd, when 20 newly emerged adult weevils were placed in each of two cages. The first examination was carried out on August 25th, when new plants were substituted for the old ones. Another examination was made on Aug. 27th. The table below shows the results. The meaning of the symbols are as in Table 8.

Fig. 23. Feeding marks of adults on leaves of various plants. The plant species and the degree of feeding marks from left to right: red clover ++++, alsike clover ++, white clover + and alfalfa (+). Drawing of bowl 2, containing plant combination I in experiment 1 (see Table 8).

Cage 1	Examination 25. 8.	27. 8.
Trifolium pratense L.	++	+
T. hybridum L.	+	(+)
Medicago sativa L.	—	(+)
Phaseolus vulgaris L.	—	—

Cage 2	Examination 25. 8	27. 8
Trifolium pratense L.	++	+
T. hybridum L.	+	+
T. medium L. Huds.	++	+
Medicago sativa L.	(+)	(+)

The experiments reported above, made to ascertain the feeding of the adults on various plant species, yielded, in the main, results similar to those carried out with larvae. In conditions permitting the adults to choose between different clover species and some other species of the *Papilionaceae* family, they clearly preferred red clover. Feeding on other clover species — alsike, white and zigzag clover — was also fairly heavy. On alfalfa, only a few feeding traces were noted, while on pea and bean plants there were none.

In the field, the adults were observed to have fed on red, alsike and zigzag clover, and apparently also on white clover.

3. *Development and occurrence on various plants — reproduction plants*

The eggs of the species developed and the incubation time was identical on all plants in which the females laid eggs in the experiment: red, alsike, zigzag and white clover, alfalfa and bird's foot trefoil. The oviposition plant thus seemed to have no effect on the incubation period.

To determine the plants on which the larvae were able to develop, observations were made on the development of larvae hatched from eggs laid on various plants in the experiments to ascertain the choice of oviposition plant. In addition, larvae of varying sizes were transferred from red clover to other plants. The larvae grew and developed into adults on alsike, zigzag and white clover, apart from on red clover, whereas larvae transferred to alfalfa, bird's foot trefoil, meadow vetchling and tufted vetch died within a few days. The mature larvae, which were in no further need of food, began constructing their cocoons on all these plants, too.

While ascertaining the effect of the plant species on the total length of the developmental period, the development of a number of eggs laid on June 15th, 1955, in red and white clover in tube rearings was observed. On red clover, adults emerged in 44 days, and on white clover in 46—50 days after oviposition. On alsike and zigzag clover, too, the developmental time is, on an average, slightly longer than on red clover, although shorter than on white clover. Thus differences in the developmental time of the species on different plants are only slight. — The difference in the total developmental time is solely due to the varying duration of the larval stage, as the plant species seems to have no effect on the egg and pupal stages.

In the field, most eggs and larvae occurred on red clover, but they were also found on alsike and zigzag clover. The table below shows the relation in the numbers of larvae on red clover and on alsike clover. It gives the number of larvae on shoot samples taken three times during the summer of 1953 from experimental area I and from an adjoining alsike clover field of the same age.

	25. 6	30. 6	1. 8.
Trifolium pratense L.	44	35	10
T. hybridum L.	7	4	1

In the samples taken at the same time, the larvae found on red clover were, on the average, appreciably bigger than those on alsike clover.

The adults, as well as the eggs, larvae and pupae, were found to occur in their greatest numbers on red clover. Adults were also found on alsike, zigzag and white clover. On the latter, no other developmental stages of the species were found in the field, but the number of examinations was not great. In investigations by SCHNELL (1955) in Schleswig-Holstein, the percentage of adult lesser clover leaf weevils among *Apion*, *Sitona* and *Phytonomus* species was 2.3 in red clover, 1.5 in alsike clover, and 0.7 in white clover.

The reproduction plants of the lesser clover leaf weevil, in which the species lays eggs that develop into adults, are, on the basis of the investigations reported above: *Trifolium pratense* L., *T. hybridum* L., *T. medium* L., Huds. and *T. repens* L. On the latter, however, only adults were found in the field. In addition, probable reproduction plants are *T. agrarium* L. em. Schreb. and *T. arvense* L., reported by TARGIONI-TOZZETTI (1888), and *T. incarnatum* L., reported by TITUS (1911).

Other plants belonging to the *Papilionaceae* family were not found to be reproduction plants of the weevil. Subjects of the investigation were *Medicago sativa* L., *Lotus corniculatus* L., *Vicia sativa* L., *V. cracca* L., *Phaseolus vulgaris* L., *Lathyrus pratensis* L., *Pisum sativum* L. and *Lupinus polyphyllus* Lindbl. In the two first-mentioned plants the females do lay eggs, and the

larvae and adults feed on them to some extent, particularly when there is a lack of food. A few very slight feeding marks were also noticed on *Vicia sativa* and *Phaseolus vulgaris.* Adult weevils will probably be found in nature on all the plants mentioned above, and apparently on many other species of the *Papilionaceae* family as well (cf. SCHNELL 1955). Nevertheless, this is not sufficient ground for describing them as reproduction plants, or even for saying that the species feeds on them.

In literature, the lesser clover leaf weevil has been reported to have inflicted damage on alfalfa, bean and common vetch, amongst other plants (see pp. 46—47). On the basis of the experiments and investigations reported above, the species does not number among the pests on these plants. When the adults suffer from an exceptionally severe lack of food, they may to some extent feed on them, however.

VII. Summary

Investigations regarding the biology of the lesser clover leaf weevil *(Phytonomus nigrirostris* Fabr.) were carried out in 1953—55 at the Department of Pest Investigation, Agricultural Research Centre, Tikkurila, partly in the field and partly in the insectarium. May, June and July, the most important months as regards the development of the species, were warmer than normal in 1953—54. The summer of 1955 greatly differed from the two previous ones: May and June were considerably colder than normal, while July was warmer than normal. In May and June, the growth of the red clover was delayed from normal by 2—3 weeks.

The species is quite common in Southern and Central Finland where red clover is cultivated, but it can also be found at Oulu (latitude approx. 65° N.).

The length of the eggs was measured as 0.53—0.75 mm (av. 0.64 mm) and their width was 0.23—0.44 mm (av. 0.34 mm). Of the nearly 4000 eggs inspected, 99.5 pc were situated in the leaflets of the red clover, 0.4 pc in the stipules and 0.1 pc in the petioles. The majority (57—74 pc) of the eggs were under the epidermis of the lower surface of the leaflets and the minority under the epidermis of the upper surface. Only exceptionally were eggs found on the surface of the leaflets. The eggs occurred either singly (43—70 pc), or in groups of 2—6 eggs. The groups in general, and the larger groups in particular, were considerably more common under the epidermis of the lower surface than under that of the upper surface.

In the experiments carried out in the insectarium, the number of eggs laid by six females in 1954 totalled 171—384 (av. 289 eggs) and in 1955 (8 females) 104—409 (av. 238 eggs). The greatest number of eggs which occurred daily totalled 25 in 1954 and 22 in 1955; the smallest number in both years was 1. The average number of eggs laid daily varied considerably, ranging in 1954 from 4.9 to 8.9 (av. 6.1) and in 1955 from 2.5 to 8.2 (av. 5.2). At higher temperatures the daily number of eggs, as well as the total, was increased, to be diminished again at lower temperatures.

The egg-laying period in the experiments carried out in the insectarium was 35—54 days (av. 47 days) in 1954 and 34—56 days (av. 46 days) in 1955. The shortest developmental period of the eggs was 8 days in both

years (av. temperature approx. 21°C), and the longest was 19 days in 1954 (approx. 14°C) and 30 days in 1955 (approx. 11.5 C). The incubation period was, for instance, 18—21 days at a temperature of 14°C, and 10—14 days at a temperature of 18°C.

For food, the larvae use almost exclusively the young parts of plants, namely, shoots developing in the stipules, as well as inflorescences just beginning to develop. On the whole, in our country the larvae of the lesser clover leaf weevil are more frequently seen inside the stipules than in the inflorescences, as the inflorescence period of the red clover usually occurs after the larval period is over. In 1953—54, only 10 pc (in the maximum case) of the larvae were located in the inflorescences; in 1955, this figure was over 60 pc (in the maximum case), due to the lower temperatures in the early summer. As the development of the red clover was less delayed in the last-mentioned year, the majority of the larvae had the possibility of living in the inflorescences. — There is normally only one larvae inside a stipule and the same in an inflorescence. No more than two larvae at a time were ever noticed in these places.

The larval period was 14—20 days (20.4—17.1°C), including the period (1—3 days) when the larva lives in the cocoon. The pupal period was 10—16 days (18.6—16.6°C). The cocoons were generally located inside the stipules and also in the inflorescences.

The average length of the adults investigated (35 specimens) was 3.64 mm and their width 1.66 mm; the size of the smallest specimen was 3.1 × 1.5 mm and that of the largest 4.0 × 1.9 mm. After emerging the adults lived in the cocoon for 1—3 days before moving elsewhere. They fed mainly on the leaves of the red clover, but feeding marks were also seen on the stipules and stems. The adults hibernate mainly in their summer biotope, the red clover field. Most of the specimens lived for one year, but some females lived for 15—16 months.

According to the observations made on the egg, larval and pupal periods, the total developmental period varied from 32 to 68 days. In 1953, the first adults appeared 54 days after the first oviposition in the field (av. temperature 15.2°C), in 1954 they appeared after 55 days (15.2°C) and in 1955 after 62 days (14.4°C). The adults from eggs laid later appeared after a considerably shorter time.

The great difference in the temperatures of the summers concerned was clearly apparent in the periods of the various developmental stages. In 1954, the adults left their places of hibernation finally on May 7th, when the first traces of their activity appeared. In 1955, this took place three weeks later (on May 28th). Similarly, in 1955 the first eggs appeared in the experimental area and in the insectarium 8 days later (on May 28th) than in the previous year (on May 20th). In both years, eggs were found during an

approximate period of 6 weeks. The first larvae (appearing on June 1st — 2nd in 1953 — 1954, and on June 27th in 1955) were delayed by nearly four weeks in the last-mentioned year. In the field, the larvae appeared during a six-week period in 1953—1954, and during a period of one month in 1955. In 1955, the pupae appeared approximately three weeks later than in the two previous years and the first adults of the new generation were two weeks later (on July 12th in 1953, on July 14th in 1954, and on July 29th in 1955). The adults started hibernation after the middle of August.

The abundance of the specimens very much depends on the food plants, the composition of the field, the age of the field (abundance of red clover), the haymaking, and the presence of natural enemies, amongst other factors.

In conditions where the adults had an opportunity of choosing their oviposition plants from among different clover species and some other plants of the *Papilionaceae* family, they clearly preferred the red clover *(Trifolium pratense* L.). Egg-laying in alsike clover, white clover and zigzag clover *(Trifolium hybridum* L., *T. repens* L. and *T. medium* L., Huds.) was also rather abundant. Very few eggs appeared in alfalfa *(Medicago sativa* L.) and bird's foot trefoil *(Lotus corniculatus* L.). The females did not lay eggs at all in other specimens of the same family, such as *Vicia cracca* L., *Pisum sativum* L. and *Lupinus polyphyllus* Lindl. The number of eggs was greatly influenced by the plant species. Only approximately a third of the number of eggs laid in red clover were noticed in alfalfa. In the experimental field, eggs were also found in red, alsike and zigzag clover.

In conditions where the larvae had on opportunity of choosing their food plants from amongst various clover species and other plants of the *Papilionaceae* family, they clearly preferred red clover. Feeding marks on alsike, white and zigzag clover were also frequent. Only a few feeding marks appeared on alfalfa and bird's foot trefoil, and fewer still on common vetch. When the larvae were in need of food, they fed to a certain extent on alfalfa and bird's foot trefoil, but died in a few days. — The influence of different food plants on adult specimens was, on the whole, similar to their influence on larvae.

On the basis of field and insectarium investigations, red clover, alsike clover, zigzag clover and white clover were found to be the reproduction plants of the species. On white clover, only adult specimens were noticed, but in the insectarium eggs laid in this plant developed and became adults. Adult lesser clover leaf weevils may also appear on several species which are not reproduction plants.

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SELOSTUS:

Tutkimuksia korvakekärsäkkään, Phytonomus nigrirostris Fabr. (Col. Curculionidae), biologiasta

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Maatalouskoelaitos, tuhoeläinosasto, Tikkurila

Tuhoeläinten elintapojen seikkaperäinen tunteminen on niiden torjunnan perusedellytys. Torjunta päämääränä suoritettiin Maatalouskoelaitoksen tuhoeläinosastolla v. 1953—55, osaston toimintasuunnitelmaan kuuluvana työnä, sekä kenttä- että insektaariotutkimuksia korvakekärsäkkään (*Phytonomus nigrirostis* Fabr.) biologiasta.

Korvakekärsäkäs kuuluu puna- ja alsikeapilan tärkeimpiin tuholaisiin maassamme. Se on varsin yleinen ja runsaslukuinen Etelä- ja Keski-Suomessa. Pohjoisin tunnettu esiintymispaikka on Oulu. Korvakekärsäkäs tunnetaan merkittävänä tuholaisena myös useissa Euroopan maissa ja Pohjois-Amerikassa. Sen torjuntaa on kuitenkin varsin puutteellisesti selvitetty. Pääasiallisena tuhontekijänä on lajin toukka, joka vioittaa korvakkeiden suojassa kehittyviä nuoria versoja sekä kukintoja. Tuho tuntuu siemensadossa, mutta lajin esiintyessä hyvin runsaana myös rehusadossa.

Lajin kehitykselle ratkaisevimmat kuukaudet touko-, kesä- ja heinäkuu olivat tutkimusvuosina 1953—54 normaalia lämpimämmät. Kesä 1955 oli sääsuhteiltaan kahdesta edellisestä, keskenään melko samanlaisesta suuresti poikkeava: touko- ja kesäkuu olivat huomattavasti normaalia kylmemmät, mutta heinäkuu lämpimämpi. Puna-apilan kehitys oli touko-kesäkuussa v. 1955 2—3 viikkoa normaalista jäljessä.

Korvakekärsäkkään munien pituudeksi mitattiin 0.53—0.75 mm (keskim. 0.64 mm) ja leveydeksi 0.23—0.44 mm (keskim. 0.34 mm). Tarkastetuista lähes 4 000 munasta sijaitsi 99.5 % puna-apilan lehdyköissä, 0.4 % korvakkeissa ja 0.1 % lehtiruodissa. Suurin osa (57—74 %) munista oli lehdyköiden alapinnan epidermiksen alla ja vähemmistö yläpinnan epidermiksen alla. Vain aniharvoissa poikkeustapauksissa löytyi munia lehdyköiden pinnalta. Munat olivat joko yksittäisiä (43—70 %) tai 2—6 munan ryhmissä.

Insektaariossa suoritetuissa kasvatuskokeissa oli v. 1954 naaraiden munamäärä 171—384 (keskim. 289) ja v. 1955 104—409 (keskim. 238). Suurin vuorokautinen munamäärä oli v. 1954 25 ja v. 1955 22, pienin molempina vuosina 1. Keskimääräinen munamäärä vaihteli eri yksilöillä melkoisesti: v. 1954 se oli 4.9—8.9 (keskim. 6.1) ja v. 1955 2.5—8.2 (keskim. 5.2). Sekä vuorokautinen munamäärä että kokonaismunamäärä suurenivat lämpötilan kohotessa ja pienenivät lämpötilan aletessa.

Muninta-aika oli insektaariossa suoritetuissa kasvatuskokeissa v. 1954 35—54 vrk (keskim. 47 vrk) ja v. 1955 34—56 vrk (keskim. 46 vrk). Lyhin todettu munien kehitysaika oli kumpanakin vuotena 8 vrk (keskilämpötila n. 21 C) sekä pisin v. 1954

19 vrk (n. 14°C) ja v. 1955 30 vrk (n. 11.5°C). Muna-aika oli esim. 14°C:ssa 18—21 vrk ja 18°C:ssa 10—14 vrk.

Toukka-aika oli 14—20 vrk (20.4—17.1°C), tähän luettuna myös se aika (1—3 vrk), minkä toukka elää kotelokopassa ennen koteloitumistaan. Koteloaika oli 10—16 vrk (18.6—16.6°C). Kotelokopat sijaitsivat yleisimmin varsien haaraantumiskohdassa korvakkeiden suojassa. Jokseenkin yhtä yleisesti niitä löytyi kukinnoista.

Tutkittujen aikuisten keskimääräinen pituus oli 3.64 mm ja leveys 1.66 mm; pienimmän yksilön koko 3.1 × 1.5 mm ja suurimman 4.0 × 1.9 mm. Kuoriutumisensa jälkeen aikuiset elivät kotelokopassa 1—3 vrk ennen liikkeelle lähtöään. Ne käyttivät ravinnokseen pääasiallisesti puna-apilan lehtiä, mutta syöntijälkiä oli myös mm. korvakkeissa ja varressa. Aikuiset talvehtivat yleisimmin puna-apilanurmessa. Useimmat yksilöt elivät n. vuoden, mutta joidenkin elinikä oli 15—16 kk.

Muna-, toukka- ja koteloajasta tehtyjen havaintojen perusteella oli lajin koko kehitysaika munasta aikuiseksi 32—68 vrk. Ensimmäisten munien kentälle ilmaantumisesta siihen, kun ensimmäiset aikuiset ilmestyivät kesti v. 1953 54 vrk (keskilämpötila 15.2°C), v. 1954 55 vrk (15.2°C) ja v. 1955 62 vrk (14.4°C). Myöhemmin kesällä munituista munista ilmaantuivat aikuiset huomattavasti lyhyemmässä ajassa.

Tutkimuskesien lämpötilaolojen suuri eroavuus ilmeni varsin selvästi eri kehitysasteiden esiintymisajassa. V. 1954 tapahtui talvehtineiden aikuisten pysyvä liikkeelle lähtö 7. V ja v. 1955 kolme viikkoa myöhemmin (28. V). Ensimmäiset munat ilmaantuivat sekä kentälle että insektaariokasvatuksiin v. 1955 8 vrk myöhemmin (28. V) kuin edellisenä vuotena (20. V). Munia löytyi kentältä kumpanakin vuotena runsaan 1 1/2 kk:n aikana. Ensimmäisten toukkien (v. 1953—1954 1—2. VI ja v. 1955 29. VII) kohdalla oli myöhästyminen pidentynyt jo miltei neljäksi viikoksi. Toukkien esiintymisaika kentällä oli v. 1953—1954 n. 1 1/2 kk:n ja v. 1955 n. 1 kk:n mittainen. Kotelot ilmaantuivat v. 1955 noin kolme viikkoa myöhemmin kuin kahtena aikaisempana vuotena, ja ensimmäiset uuden sukupolven aikuiset kaksi viikkoa myöhemmin (v. 1953 12. VIII, v. 1954 14. VII ja v. 1955 29. VII). Aikuisten siirtyminen talvehtimispaikkoihin alkoi elokuun puolivälin paikkeilla.

Lajin esiintymisrunsauteen vaikuttavat mm. ravintokasvilaji, nurmen kasvilajikoostumus ja siinä eri lajien runsaussuhteet, nurmen ikä (puna-apilan runsaus), heinänteko ja luontaiset viholliset. Suhteellisesti suurimmat tuhot sattuvat yleensä kolmannen vuoden ja sitä vanhemmissa puna-apilanurmissa, mutta jo toisen vuoden nurmessa tuho on usein tuntuva. Mitä aikaisemmin heinänteko tapahtuu, sitä suurempi on sen toukkia tuhoava vaikutus. Jos puna-apila niitetään jo aikaisella kasvuasteella, 2—3 viikkoa ennen kukintaa, tuhoutuvat miltei kaikki toukat.

Sellaisissa olosuhteissa, joissa aikuisilla oli mahdollisuus valita munintakasvinsa eri apilalajien ja joidenkin muiden palkokasvilajien joukosta, ne munivat selvästi eniten puna-apilaan. Muninta alsike-, valko- ja metsäapilaan oli myös melko runsasta. Sinimailaseen ja rantamaitteeseen ilmestyi munia vain hyvin vähän. Muihin tutkittuihin palkokasveihin (hiirenvirna, peltoherne ja monilehdykkäinen lupiini) eivät naaraat munineet lainkaan. Kasvilajilla oli huomattava vaikutus munamäärään. Sinimailasessa naaraiden munamäärä jäi vain noin kolmannekseen siitä, mikä se oli puna-apilassa. Kentältä löydettiin munia puna-, alsike- ja metsäapilasta.

Toukat käyttävät ravinnokseen miltei yksinomaan nuoria kasvinosia, puna-apilan korvakkeiden suojassa kehittyviä versoja ja kehityksensä alussa olevia kukintoja. Yleensä korvakekärsäkkään toukat esiintyvät maassamme runsaslukuisempina korvakkeiden suojassa kuin kukinnoissa. Tämä johtuu siitä, että kukinnot ilmaantuvat puna-apilaan tavallisesti vasta toukkien runsaimman esiintymisen ajan ollessa jo ohi.

V. 1953—1954 oli toukista niiden esiintymisajan loppupuolellakin vain alle 10 % kukinnoissa, mutta v. 1955 paljon runsaammin, eräissä tapauksissa yli 60 %.

Sellaisissa olosuhteissa, joissa toukilla oli mahdollisuus valita ravintokasvinsa eri apilalajien ja joidenkin muiden palkokasvien joukosta, toukat söivät selvästi eniten puna-apilaa. Myös alsike-, valko- ja metsäapilan syönti oli runsasta. Sinimailaseen ja rantamaitteeseen ilmestyi vain muutamia syöntijälkiä. — Siitä, miten aikuiset käyttävät eri kasveja ravinnoksi, saatiin pääpiirtein samanlaiset tulokset kuin toukilla.

Kenttä- ja insektaariotutkimusten perusteella todettiin lajin lisääntymiskasveiksi puna-, alsike-, metsä- ja valkoapila. Viimeksi mainitussa ei kentällä esiintynyt lajin muita kehitysasteita kuin aikuisia, mutta insektaariokasvatuksissa siihen munitut munat kehittyivät aikuisiksi asti. Aikuisia korvakekärsäkkäitä saattaa esiintyä lukuisissa sellaisissakin kasveissa, jotka eivät ole lajin lisääntymiskasveja.

Suoritetuissa tutkimuksissa on selvitetty yksityiskohtaisimmin niitä lajin biologian kohtia, jotka ovat torjunnan selvittämisen kannalta tärkeimpiä. Tällaisia ovat erityisesti aikuisten talvehtimispaikoista liikkeellelähdön aika, muninnan alkamisaika, munien sijainti ja toukkien elintavat. Rinnan biologisten tutkimusten kanssa on suoritettu alustavia torjuntatutkimuksia, mutta ne on jätetty tässä julkaisussa selostamatta.

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